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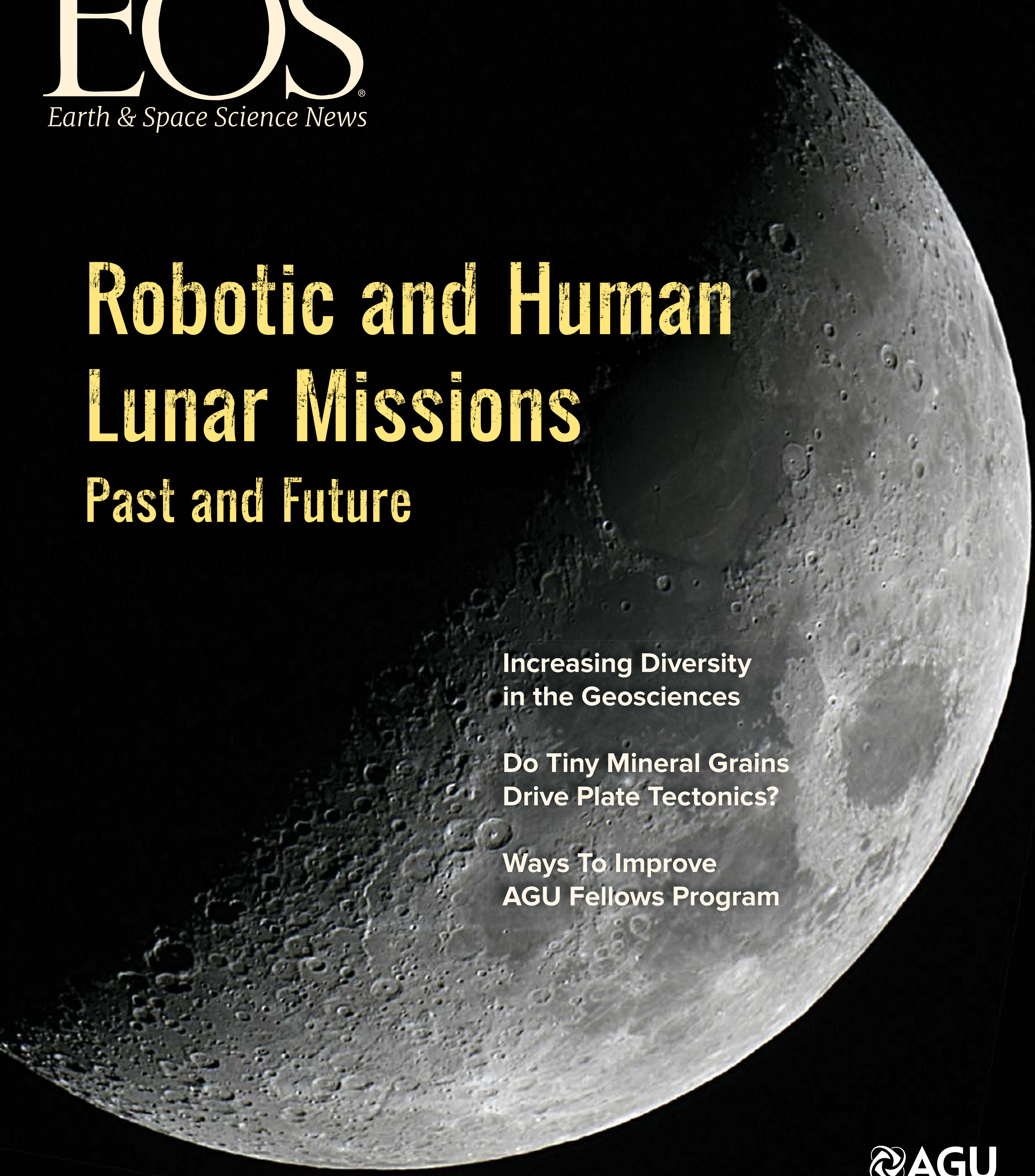
Earth & Space Science News



Robotic and Human Lunar Missions

Past and Future

Increasing Diversity in the Geosciences

Do Tiny Mineral Grains Drive Plate Tectonics?

Ways To Improve AGU Fellows Program

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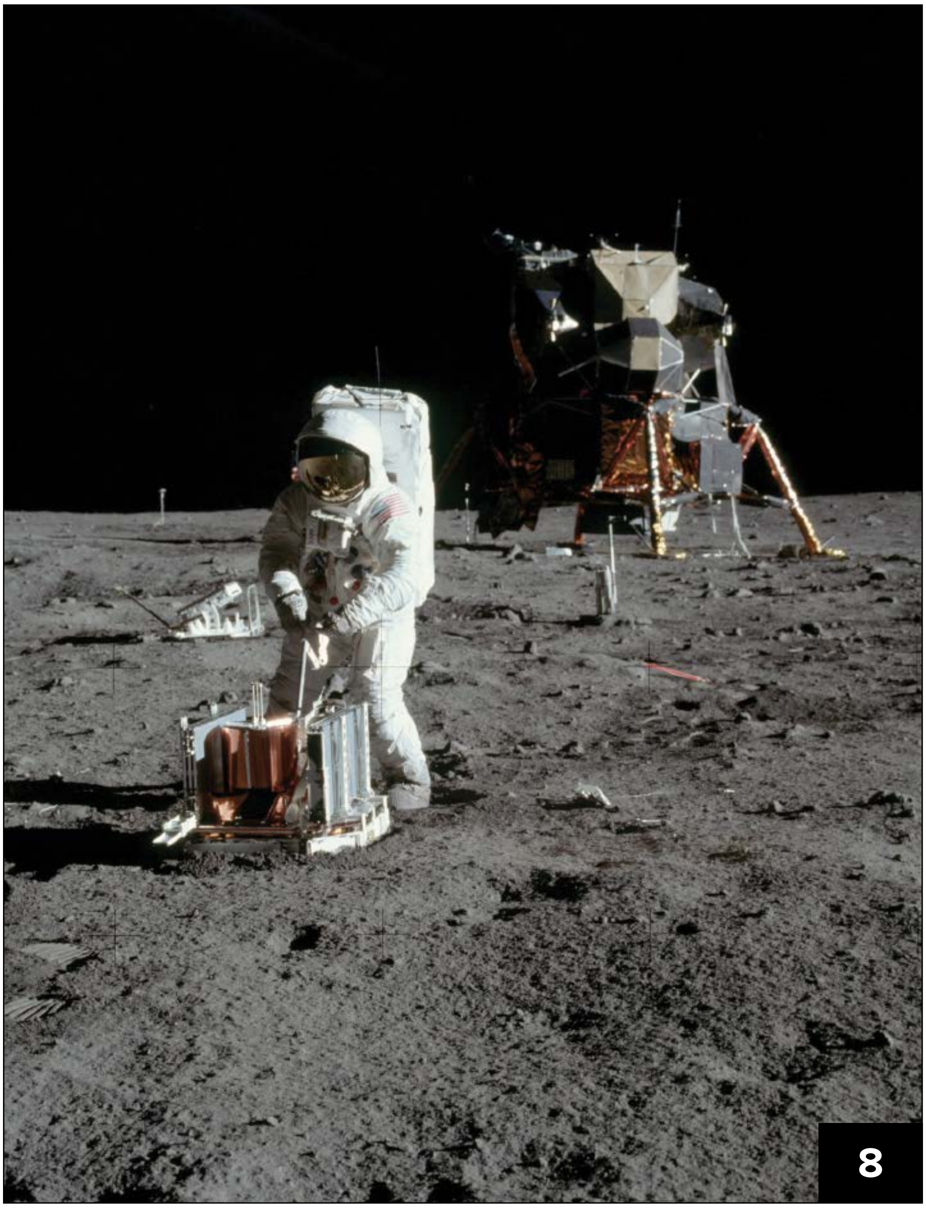

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Tiny Mineral Grains Could Drive Plate Tectonics

The idea of plate tectonics—that Earth's plates smash into each other to form mountains, slide underneath each other to form ocean trenches, and pull apart to form new oceans and continents—is well known. The underlying mechanism driving these processes, which scientists think may be vital to the evolution of life, remains unclear. No one knows for sure how plate tectonics even evolved.

At a global scale, individual plates can be easy to see—their borders are defined by where earthquakes occur. Global perspectives have also allowed scientists to precisely map the movement of plates over millennia by tracking magnetic signatures on the bottoms of the oceans. In addition, vast networks of GPS receivers can also track minute movements of plates today.

However, investigating the factors that first triggered plate tectonics requires a different perspective, said David Bercovici, a geophysicist from Yale University. He explained this perspective in a session at the 2015 annual conference of the American Association for the Advancement of Science in San Jose, Calif.

To fully understand plate tectonics, he said, "We need to zoom in from the global scale into the microscale."

A close-up of mylonite made up of a green form of muscovite mica. Scientists think mylonite plays a key role in initiating the tectonic movement of plates.

It All Comes Down to Grain Size

At many plate boundaries, scientists find a metamorphic rock made of deformed, very fine grained minerals called mylonite. The origin of mylonite is still unknown, Bercovici said.

The grains within mylonite are much smaller than the rocks in the plates around them, which makes mylonite relatively weak. Because of this relative weakness, mylonite "seems to support or permit very, very rapid, focused deformation," said Bercovici.

> To fully understand plate tectonics, scientists have to zoom in from the global scale to the microscale.

Bercovici and colleagues suggest that the small-grained mylonite fuels a feedback mechanism that creates the weak spots on Earth that we know as active plate boundaries.

"As you deform [mylonite], somehow the grains in rocks become so small that it softens the rock up, and softened rock supports rapid deformation to allow you to have these plate boundaries," Bercovici said.

Scientists remain in the dark about exactly how mylonite forms at a granular level. However, decades of collaborative research gave Bercovici's team an idea.

In most rocks, minerals grow grain by grain, gobbling up the grains next to them—much like how the bubbles in foam get bigger by "eating" neighboring bubbles. When a growing mineral grain swells up against a different type of mineral, its growth is blocked by the boundary between the two minerals in a process called "pinning." This process forces the grains into smaller and smaller sizes by further damaging the grain-to-grain interface.

As the grains get smaller and smaller, the resulting mylonite gets weaker and weaker.

"By damaging the [grain] interface, we can drive the grains to smaller sizes and therefore get the self-softening feedback mechanism," Bercovici said.

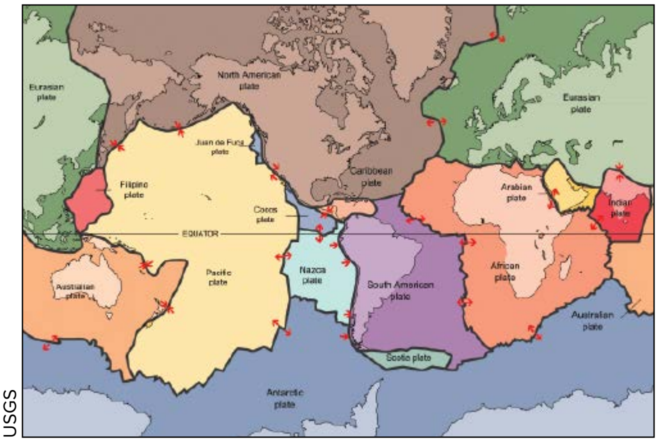
Origins of Plate Boundaries

The last piece of the puzzle required a peek back in time—via exhaustive research on samples of 4.4-billion-year-old zircon. This zircon likely formed when granites crystallized from magma heated by the hot fluids that sweat off subduction zones.

The age of the zircon falls as much as 1 billion years before scientists think plate tectonics became a global phenomenon. This presents a puzzle—how did a mineral likely formed by subduction processes crystallize before subduction became mainstream? Bercovici speculates that primitive subduction zones might have formed on Earth's surface early in its history, when cool, heavy mantle rock near the surface began to drip down deeper into the mantle, pulling overlying crust down with it.

Bercovici applied his theoretical model of mylonite formation to simulations that mimicked the formation of subduction zones. He found that where primitive subduction formed, a mylonitic-type weak zone formed.

"When the drip-like subduction ceased and started again elsewhere, it left behind a weak zone that would persist without healing for many millions of years," Bercovici said.



USGS

Fine-grained mylonite is found at plate boundaries around the world. Scientists are seeking to understand how this mineral relates to the evolution of plate tectonics itself.

More weak zones accumulated, which would eventually connect to make a continuous plate boundary, complete with a spreading center and strike-slip faults. Bercovici compared these weak zones to scars on the Earth's surface that never healed. "Once I've built up enough of these scars, it persists long enough to give me a full-blown plate," Bercovici said.

Bercovici also applied his calculations to models of Venus. However, he found that the feedback mechanism could not exist on Venus because, thanks to high surface temperatures, mineral grains would be able to grow fast enough to "heal" the deformed areas of lithosphere. On Earth, the relatively low temperature slows down this healing process.

A Large-Scale Mystery

Although the research may be the first to show how initial damage in surface plates can propagate through tectonic cycles, it needs to be tested using more realistic rock mechanics, said Jun Korenaga, professor of geophysics at Yale University.

In addition, he noted that the comparison to Venus is moot because the planet's soaring temperatures are probably due to its lack of plate tectonics.

"In the hypothetical early Venus, the surface temperature could be as low as the current Earth," said Korenaga, which would mean its surface would not have been able to heal from weak-zone fractures.

Although Bercovici's work gives clues about how plates on Earth started to move, it does not solve the plate tectonic mystery completely. For example, what happens when two continents collide? In the future, Bercovici hopes to include the effects of continent-to-continent interaction in his models of mylonite-induced tectonics.

By **JoAnna Wendel,** Staff Writer

Volcanic Eruptions Steer Conversations on Climate Intervention


USGS/PHIVOLCS

The plume from the eruption of Mount Pinatubo in 1991 spewed about 20 million tons of sulfur dioxide into the stratosphere. Dispersion of this gas reduced global average temperatures by about 0.5°C between 1991 and 1993.

From detonating nuclear weapons in the atmosphere to trying to move hurricanes, history is filled with scientists proposing eccentric strategies to control the climate. The latest idea to gain traction involves tweaking Earth's albedo by injecting the stratosphere with sulfur aerosols in an effort to reflect more sunlight back into space.

When airborne sulfur dioxide dissolves in water vapor, sulfuric acid forms. This acid then dissociates into aerosolized sulfate particles, which scatter sunlight away from Earth. Sulfur aerosols also can affect cloud formation by increasing cloud height, reflectivity, and longevity. Scientists and engineers find these properties attractive—the more sunlight Earth reflects, the less heat it absorbs, leading to a cooler planet.

Injecting the stratosphere with sulfur aerosols using balloons, planes, drones, or a combination of the three wouldn't be too expensive, explained Alan Robock, a geophysicist at Rutgers University. Robock spoke at a panel discussion at the 2015 meeting of the American Association for the Advancement of Science, held 12–16 February in San Jose, Calif.

However, he and other scientists worry about the global consequences of such a feat. To gain more insight into the way sulfur aerosols affect the globe, scientists turn to nature—specifically, volcanoes.

Volcanic Domino Effect

With every large eruption, volcanoes spew thousands of tons of sulfuric aerosols into the stratosphere and cause brief periods of global cooling. By modeling the effects of large volcanic eruptions, Robock and other scientists found that although injecting the atmosphere with sulfur aerosols could put a dent in global warming by increasing the amount of light reflected away from Earth, the risk of global consequences, such as resulting drought or degradation of the ozone layer, may outweigh any temporary benefits.

The diary of a French nobleman, the count of Volney, supports the model's findings. According to Robock, the count was living in Cairo in 1783, the same year that the Laki volcano erupted in Iceland. That year, the count reported in his diary that the annual flooding of the Nile, which provides water and nutrients to Egypt, had not been sufficient. Even the next year, flooding was not nearly as widespread, the count wrote.

Months after the eruption, "there was a famine in Egypt, and by the next year, one sixth of the population had either died or left," Robock said. Famine in India and Japan also struck soon after.

More recently, modern technology has recorded the global effects of large volcanic eruptions. In 1912, for instance, an eruption of Katmai volcano in Alaska preceded record low river flow in both the Niger and the Nile. In 1991, Mount Pinatubo in the Philippines erupted, resulting in record low precipitation in many regions of Earth.

Because stratospheric sulfur aerosols absorb as well as reflect sunlight, the warmer particles, when present in high concentrations, seem to decrease precipitation around the globe by inhibiting the formation of storm clouds. In addition, sulfur aerosols provide a surface for hydrochloric acid (emitted industrially and by volcanoes) to break down into ozone-destroying chlorine and chlorine monoxide, which degrade the atmospheric shield protecting Earth from the Sun's ultraviolet rays.

Untestable Consequences

In addition to changing precipitation rates and triggering destruction of ozone, climate engineering via stratospheric injection of sulfur aerosols could have unknown consequences for other natural processes, such as plant or wildlife ecologies, Robock said.

Implementing any plan to deliberately change the climate also poses practical challenges. For example, who would control the technology? What steps would be taken to prevent accidental releases of too much aerosol? As Robock asked, how would nations decide "whose hand is on the thermostat?"

Geoengineering—Not a Silver Bullet

Because of the unknown consequences of climate intervention with aerosols, a new report by the National Research Council (see http://bit.ly/EOSNRC), discussed by the panel, concluded that geoengineering, or "climate intervention," is not the best way to combat climate change.

"There is no silver bullet," said panel speaker Marcia McNutt, editor in chief of *Science* magazine and former director of the U.S. Geological Survey. "After looking very seriously at methods of climate intervention, we still came to the conclusion that efforts to address climate change should continue to focus most heavily on mitigating greenhouse gas emissions."

The report also noted that continuing research into sulfur aerosol injection and other human-driven avenues of climate intervention, such as carbon sequestration or alternative ways to modify Earth's reflectivity, will be important additions to climate mitigation.

By **JoAnna Wendel,** Staff Writer

Milestones: Honoring Earth and Space Scientists

Tekla Harms, a professor of geology at Amherst College, has received the Outstanding Educator Award from the Association for Women Geoscientists (AWG) for "inspiring Earth scientists, fostering an appreciation for all things geological, and for being a powerful role model and mentor."

Sir Brian J. Hoskins, chair of Imperial College London's Grantham Institute for Climate Change and professor of meteorology at University of Reading, has been awarded the International Union of Geodesy and Geophysics (IUGG) Gold Medal for "his scientific contributions that have been pioneering and profound in almost all aspects of the atmospheric and climatological sciences, with strong linkages to IUGG and its Associations."

Rebekah Levine, of the University of New Mexico, has received the Susan Takken Student Research Presentation Travel Award from AWG.

Jerry Miller, formerly president of the consulting firm Science for Decisions, has been appointed as the National Research Council's director of science and technology for sustainability.

Kyungjin Min and **Kelly Logan**, of the University of Kansas, have received graduate research scholarships from AWG.

Susan Nissen received the President's Award from AWG for her "guidance and leadership to AWS during our 2013–14 rebranding and rebuilding program."

James O'Brien, Robert O. Lawton Distinguished Professor of meteorology and oceanography, emeritus, at Florida State University's Center for Ocean-Atmospheric Prediction Studies, has been selected as a fellow by IUGG.

Tim Palmer, Royal Society Research Professor at Oxford University, Oxford, U. K., has been honored by Queen Elizabeth and was included in the New Year's honor list as Commander of the British Empire (CBE) for "services to science."

Camille A. Partin, an assistant professor in the Department of Geological Sciences at the University of Saskatchewan, has received the Exchange Award from AWG for her work that "elevates the technical contributions of women to geoscience."

Khalia Payton, of Fort Valley State University, received a minority scholarship from AWG.

Stephen Sparks, a volcanologist at University of Bristol, has won the 2015 Vetlesen Prize for his contributions to the field of volcanology. Sparks will be awarded a medal and $250,000 at a ceremony in New York in June.

Dennise Templeton, a postdoctoral researcher at Lawrence Livermore National Laboratory, received special recognition from AWG for her "dedication to outreach" that helped grow ASW's membership.

More than a dozen American Geophysical Union (AGU) members received gold medals from the U.S. secretary of commerce for their extraordinary or prestigious contributions:

John J. Bates, principal scientist for remote sensing at the National Climatic Data Center at the National Oceanic and Atmospheric Administration (NOAA) and the National Environmental Satellite Data and Information Service and AGU Board member; **Thomas Delworth**, a research scientist at NOAA's Geophysical Fluid Dynamics Laboratory, Princeton University, N. J.; **Keith W. Dixon**, research meteorologist at NOAA's Geophysical Fluid Dynamics Laboratory; **Gerard J. Fryer**, senior geophysicist at NOAA's Pacific Tsunami Warning Center, Ewa Beach, Hawaii; **Thomas Richard Karl**, director of NOAA's National Climatic Data Center, Ashville, N. C.; **Christopher W. Moore**, research scientist in the University of Washington's College of the Environment, Seattle; **Jeffrey L. Privette**, acting division chief of NOAA's National Climatic Data Center; **Nancy A. Ritchey**, archive branch chief at NOAA's National Climatic Data Center; **Vasily V. Titov**, chief scientist at NOAA's Center for Tsunami Research, Seattle, Wash.; **Gabriel Andres Vecchi**, oceanographer at NOAA's Geophysical Fluid Dynamics Laboratory; David Walsh, oceanographer at NOAA's Pacific Tsunami Warning Center; **Dailin Wang**, oceanographer at NOAA's Pacific Tsunami Warning Center; Paul Whitmore, director of NOAA's West Coast and Alaska Tsunami Warning Center, Palmer, Alaska; **Andrew T. Wittenberg**, physical scientist at NOAA's Geophysical Fluid Dynamics Laboratory; and **Fanrong Zeng**, research meteorologist at NOAA's Geophysical Fluid Dynamics Laboratory.

Other AGU members received silver medals from the U.S. secretary of commerce for their extraordinary or prestigious contributions:

Michael B. Ek, research meteorologist at NOAA's Cooperative Remote Sensing Science and Technology Center, New York, N. Y.; **Martin P. Hoerling**, meteorologist at NOAA's Earth System Research Laboratory, Boulder, Colo.; **Fiona Horsfall**, chief of NOAA's Climate Service Division, Silver Spring, Md.; **Jin Huang**, director of the Climate Test Bed branch of NOAA's Climate Prediction Center, College Park, Md.; **Annarita Mariotti**, program manager in NOAA's Climate Program Office, Silver Spring, Md.; **Kingtse C. Mo**, physical scientist at NOAA's Climate Prediction Center; **Nicole M. Kempf McGavock**, service hydrologist at NOAA's National Weather Service Weather Forecast Office, Tulsa, Okla.; and **Roger S. Pulwarty**, physical scientist at and director of the National Integrated Drought Information System at NOAA's Earth System Research Laboratory.

Correction

The article titled "Pacific plate's underbelly revealed through explosive means" in the 1 March *Eos* magazine incorrectly stated that graduate students had detonated several explosives. The explosives were actually detonated by licensed experts. The online article has been corrected. *Eos* regrets this error.

Developing Databases of Ancient Sea Level and Ice Sheet Extents

PALSEA2 Workshop

Lochinver, Scotland, 16–22 September 2014

The postglacial landscape of northwestern Scotland was the backdrop for a workshop on maximizing the potential of data on past ice sheet and sea level variability. Scientists gathered in Lochinver, Scotland, in mid-September for the 2014 Paleo Constraints on Sea Level Rise (PALSEA2) meeting, which consisted of 3 days of field discussions followed by 2 days of presentations (http://bit.ly/2014PALSEA2).

The Assynt Mountains provided an inspirational view for debates on the evolving interpretations of physical evidence for ice sheet development in the region. Here trimlines were once thought to delineate the maximum height of the British and Irish Ice Sheet during the last glaciation but are now interpreted as indicating a thermal boundary in the ice sheet, above which the cold-based ice will act to protect rather than erode the mountain surface it is in contact with.

The workshop focused on reducing uncertainty about how ice sheet and sea level data are compiled, structured, and shared. For instance, creation of a database of sea level indicators around Britain and Ireland led to the conclusion that the ice models, with a maximum elevation constrained by the trimlines, did not contain enough ice volume at the Last Glacial Maximum to explain patterns of subsequent sea level change. Comprehensive data sets on other now-gone ice sheets showed that only through such databases could continental-scale questions be addressed.

In another more recent example, a compilation of GPS data from Antarctica indicates unstable advance and retreat of portions of the West Antarctic Ice Sheet during the late Holocene, where previously monotonic advance had been assumed. In addition, widely distributed records are required to constrain variations in sea level caused by growth and melt of past ice sheets.

How, then, should these data sets be structured for analysis? Different approaches were presented over the course of the meeting, from categorizing a landscape by exploring it on foot to turning to extensive literature reviews that capture untapped potential in metadata.

Presentations that brought disparate data sets together, clarified assumptions, and applied transparent and consistent models of uncertainty demonstrated exciting results. Specific talks included one on a recent grant award to create a portal that will standardize uranium-thorium age dating calculations,

The workshop focused on reducing uncertainty about how ice sheet and sea level data are compiled, structured, and shared.

allowing comparison of data across individual studies. Another presentation offered analysis of a data set developed from an extensive literature review that describes new species-specific effects on sea level reconstruction using fossil corals.

All of those involved in the generation of data, from field observations to models, share a responsibility to ensure that the work is as transparent as possible and is communicated via publication vehicles that recognize and support the diverse needs to which database content may be directed. To support this aim, workshop participants committed to production of a best practices document and working protocols for collating sea level and ice sheet indicators. Those involved anticipate that the documents and protocols will be ready for public discussion in 2015.

Tom Bradwell, BGS

Workshop attendees hand-core sediments in Loch Laxford, a salt marsh within Assynt's postglacial landscape.

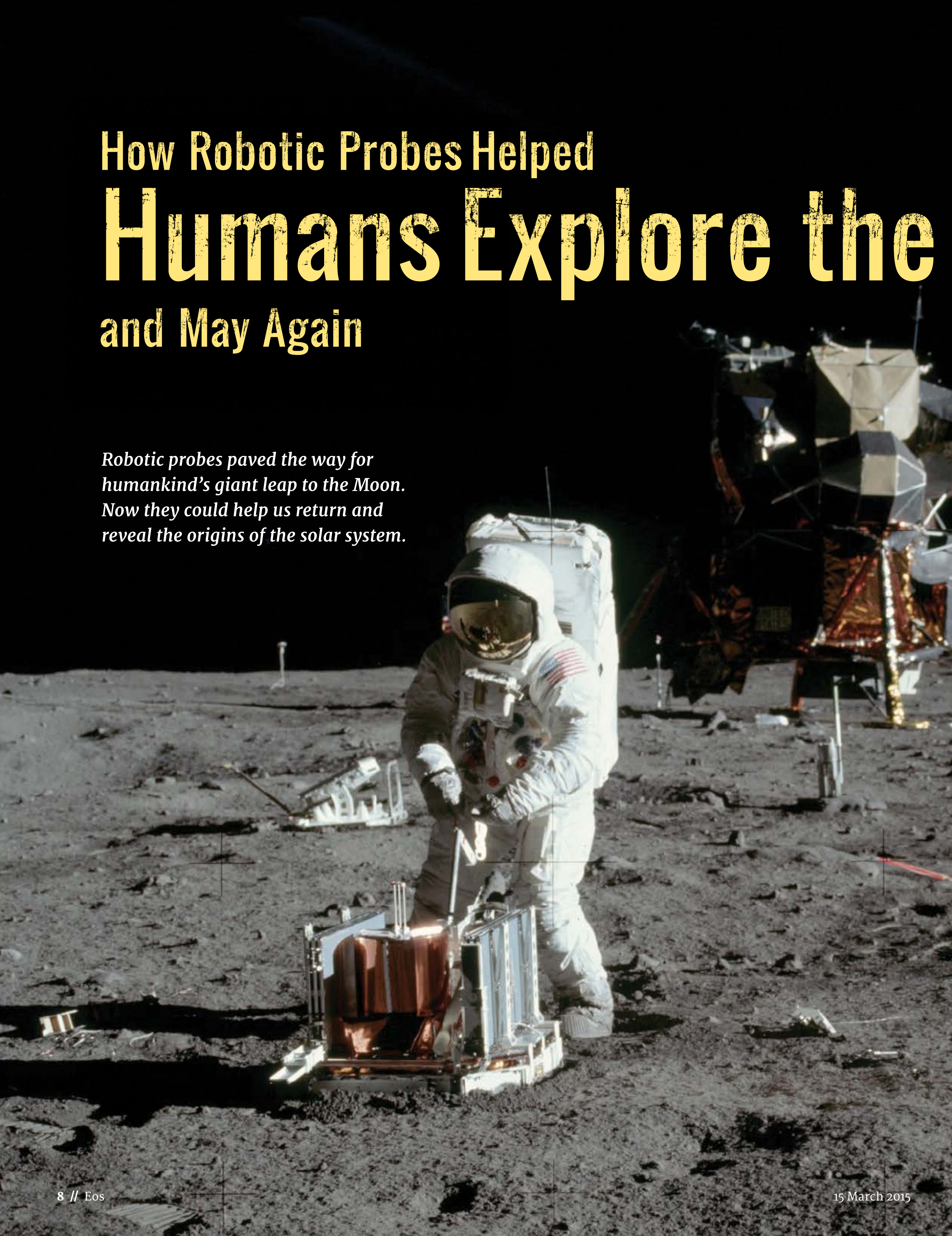
Acknowledgments

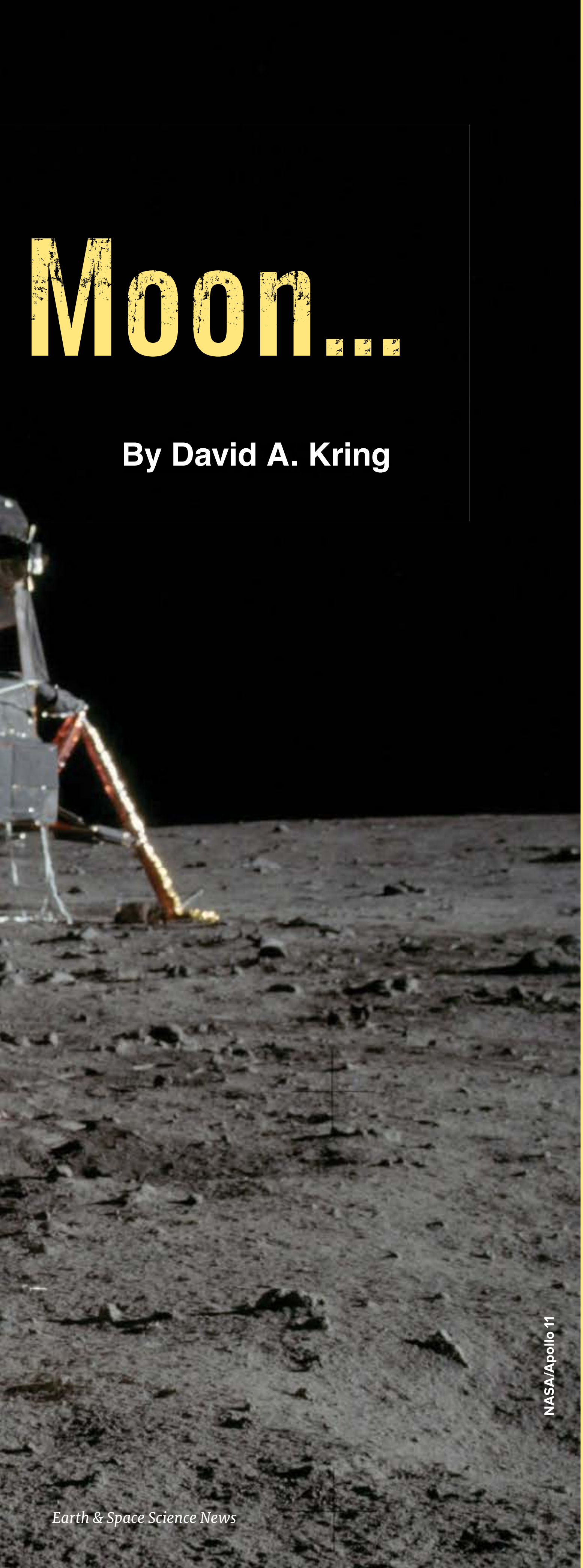
Antony Long and Natasha Barlow of the Department of Geography, Durham University, organized the meeting, with funding from the Past Global Changes program and the International Union for Quaternary Research.

By **Felicity Williams,** Ocean and Earth Science, National Oceanography Centre, University of Southampton, Southampton, UK; email: felicityhwilliams@gmail.com; **Nadine Hallmann,** Aix-Marseille Université, Centre National de la Recherche Scientifique, Institut de Recherche pour le Développement, Centre Européen de Recherche et d'Enseignement des Géosciences de l'Environnement, Aix-en-Provence, France; and **Anders Carlson,** College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis

How Robotic Probes Helped Humans Explore the Moon and May Again

Robotic probes paved the way for humankind's giant leap to the Moon. Now they could help us return and reveal the origins of the solar system.





Moon...

By David A. Kring

NASA/Apollo 11

Fifty years ago, on 17 February 1965, NASA launched the Ranger VIII robotic spacecraft toward the Moon. Three days later, the vehicle provided the world's first high-resolution glimpse of what would become Tranquility Base—the landing site of Apollo 11, where humans first stepped onto another planetary surface.

Together, the Ranger VIII results and subsequent Apollo 11 mission illustrate the tremendous value of an integrated robotic and human space exploration program. Uncrewed craft snapped pictures for mission planning and tested landing technologies. However, only Apollo's human crews could perform the intensive field work that paved the way for that era's scientific legacy.

These lessons may help guide the international scientific community as it considers future plans for lunar exploration. They point the way to a new series of lunar missions in which robotic spacecraft and humans could work together to solve the most pressing mysteries surrounding our solar system's formation.

Beginning with Impact

The U.S. government started the Ranger program in 1959 to conduct lunar science and compete with the Soviet Union's Luna program. However, in 1962, when President Kennedy announced plans to safely land astronauts on the Moon and return them to Earth, NASA redirected Ranger to support this effort, dubbed the Apollo program.

The Ranger program's primary objective involved characterizing the fine-scale structure of the lunar surface and thus determining if robotic and human missions could land on the surface safely [*Trask*, 1970]. The Ranger spacecraft did so by flying toward the Moon, taking photographs at ever-lower altitudes until they hit the lunar surface.

NASA/JPL

The Ranger VIII spacecraft.

Ranger VIII was the second successful mission in a series of nine spacecraft. It targeted one of the Moon's dark plains—formed by ancient lava flows since cooled into basalt—called Mare Tranquillitatis, Latin for the "Sea of Tranquility." Scientists studying lunar photographs, made with telescopes on Earth, found the plain alluring in part because it was relatively flat terrain close to the equator—attributes that made it more accessible for the first attempt at landing a crew on the Moon. The spacecraft carried six television cameras with different exposure times, fields of view, lenses, and scan rates.

In the 23 minutes before crashing into the lunar surface, Ranger VIII continually transmitted back to Earth full scans from its wide-angle camera A and narrow-angle camera B, providing 60 and 90 frames,

Apollo 11's mission to the Moon relied, in part, on data from Ranger VIII, its first robotic precursor.

LPI

A shaded relief chart made by Ranger VIII of the Sabine Region (roughly between 3.00°N and 1.00°S and 19.00°E and 24.00°E). The chart includes the area where Apollo 11's Eagle lander touched down, roughly near the center of the map's right edge. Scale is 1:250,000.

respectively, with about 5 seconds between frames on each camera. Camera B pointed farther south than camera A and captured several pictures of the terrain that would become Tranquility Base from an altitude as low as 229 kilometers. The spacecraft hit the lunar surface 68 kilometers north-northeast of what would later become Tranquility Base.

Scientists used the images to make a series of shaded relief charts with depths of impact craters estimated using shadow lengths. In parallel and with the same data, the U.S. Geological Survey (USGS) generated a series of geologic maps for the Moon.

Using Ranger VIII images, *Wilshire* [1967] completed a preliminary map of the Sabine Region, including the area where Apollo 11 would land, at a 1:250,000 scale. However, work on Ranger-based maps eventually slowed as personnel began shifting to NASA's next phase of robotic lunar exploration: sending craft to orbit and land on the Moon.

Orbiters and Landers

NASA began the Lunar Orbiter (LO) program in 1964, launching five spacecraft specifically designed to photograph potential Apollo landing sites. From the Lunar Orbiter images, officials selected eight sites for detailed study. The USGS assigned *Grolier* [1970a, 1970b] the task of unraveling the geology of the Mare Tranquillitatis site, also known as Apollo Landing Site 2. He based his map principally on seven high-resolution images that LO II acquired in November 1966.

The final phase of NASA's robotic Apollo preparations was to demonstrate landings themselves and test surface conditions. To do this, NASA initiated the Surveyor program while lunar photogeologic studies were under way. Within a year of the LO II flight, Surveyor V landed in a small 9 × 12 meter crater 25 kilometers northwest of what would become Tranquility Base.

Surveyor V survived three lunar nights (14 Earth-day periods without sunlight), finally succumbing and going dark after about 107 Earth days. Surveyor V, the first lunar lander to carry an alpha particle backscattering instrument, produced the first estimates of the lunar surface's chemical composition.

Excited, geologists confirmed that the maria were composed of basalt, meaning the Moon was a differentiated body with a crust derived by partial melting of a mantle with a low silica content.

Astronaut Harrison Schmitt used the last image taken from Ranger VIII to develop a hypothetical moonwalk route around a hypothetical lander in Mare Tranquillitatis.

Choosing Tranquility Base

After Surveyor V and the success of Apollo 8, the first human mission around the Moon, researchers still had not decided on the site for the first lunar landing. The Ranger VIII, LO II, and Surveyor V spacecraft had provided important precursor data for Apollo Landing Site 2, increasing its favorability. In addition, in 1966, astronaut Harrison Schmitt (who later flew on Apollo 17) had used the last image from camera B on Ranger VIII to develop a hypothetical moonwalk route around a hypothetical lander in Mare Tranquillitatis [*Schmitt*, 1966].

This mapping exercise provided a measure of mission reality that did not exist for any other landing site. Schmitt used it to argue that the simulated landing of the lunar module (LM) in the upcoming Apollo 10 mission should be above that site. Schmitt won his case, and Apollo 10 performed a dress rehearsal for Apollo 11 landing over Apollo Landing Site 2.

In June 1969, map makers with the U.S. Army delivered to NASA 116 charts and geologic maps, complete with NASA's robotic images and the USGS's geologic interpretations [*U.S. Army Topographic Command*, 1969]. The Apollo 11 astronauts carried these with them when they launched the following month.

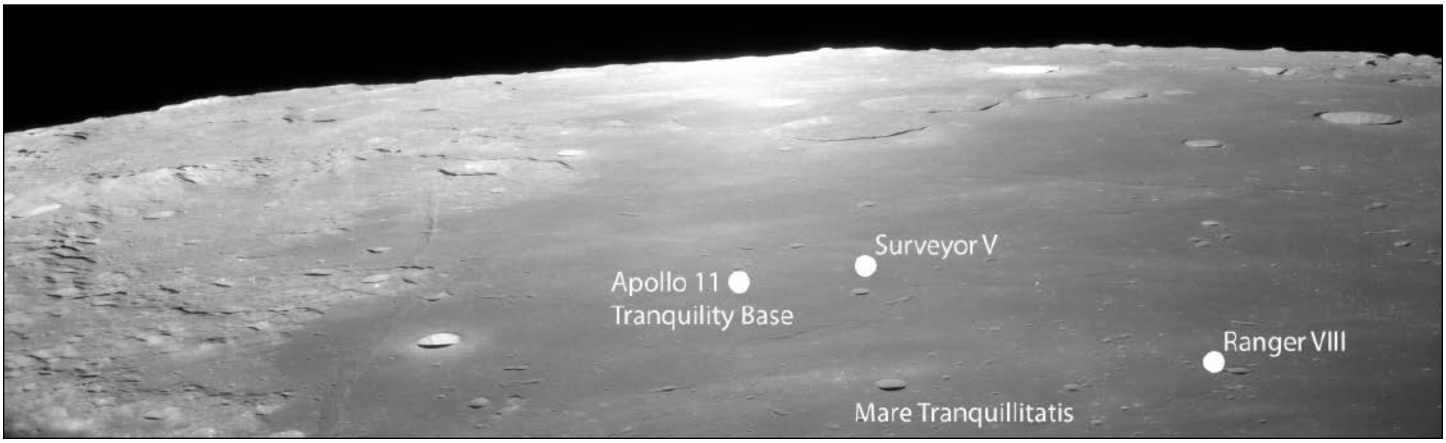
The charts and photogeologic maps of the landing area included maps at 1:100,000 and 1:25,000 scales that mapped out the anticipated landing zone and the boulders and craters that Apollo 11's lander would have to dodge.

The Eagle Has Landed…Where?

As Apollo 11's "Eagle" LM descended toward the lunar surface on 20 July 1969, carrying Neil Armstrong and Edwin "Buzz" Aldrin, a cascade of factors knocked the Eagle off course. These included the initial jolt of undocking from Apollo 11's Command Service Module (CSM), a series of test firings of the Eagle's thrusters, and variations in the Moon's gravity field encountered during the descent [*Mission Evaluation Team*, 1971].

Although the Eagle was flying over the geology mapped on the 1:25,000 charts, the crew did not know where they were on those charts. Occupied by resolving multiple alarms during the descent, they did not have an opportunity to monitor the landscape until they found themselves less than 600 meters above the surface [*Mission Operations Branch*, 1969]. By that point, Armstrong and Aldrin were not where they expected to be, and their trajectory would take them beyond the LO II high-resolution photographic coverage that had been used to certify safe landing sites.

Armstrong and Aldrin landed several kilometers west and south of their target, about 1.5 kilometers beyond the geology mapped on the 1:25,000 charts created from LO II data. They ended up in the older of two mare surfaces shown on the 1:100,000 geology map. At the time, however, they had no landmarks to place themselves. Michael Collins in the orbiting CSM could not locate the Eagle either.



NASA AS11-41-6091

Mare Tranquillitatis (the Sea of Tranquility), showing the crash site of Ranger VIII, the landing site of Surveyor 5, and Apollo 11's Tranquility Base.

A Scientific Bonanza

Despite the initial uncertainties in the LM's position, the value of a sample return mission involving a crew soon became obvious from the scientific bonanza that followed. This value only grew with each subsequent Apollo mission.

Analysis of the returned samples showed Mare Tranquillitatis to be volcanic, composed of at least two relatively iron- and titanium-rich basalts that were very old (3.6–3.9 billion years old). The regolith—lunar "soil"—also contained igneous dust and loose rocks characterized by plagioclase feldspar. Distant impact cratering events in the highlands likely kicked up this anorthositic material.

Petrological and geochemical analysis of this material led to the completely novel idea that an extensive magma ocean covered the early Moon and that the lunar crust formed from material floating to the top of this rapidly solidifying ocean.

Finally, several key studies of Apollo 11 samples and photography strongly suggested that most craters on the Moon formed from impacts, not from volcanic eruptions.

Geologists generated these big ideas of the Moon's evolution after analyzing samples collected from only 2.2 hours of astronauts' field work. In addition, during that time, Armstrong and Aldrin also managed to deploy a television camera, an experiment to measure solar wind composition, seismic monitoring instruments, a lunar dust detector, and a mirror for Earth-based laser ranging experiments, the latter of which remains in use.

To the Moon Again and Beyond

On 5 December 2014, NASA launched the first test flight—uncrewed—of its next-generation Orion crew vehicle. It was propelled to an altitude about 15 times higher than the International Space Station. Orion then returned to Earth at 80% of the speed of a spacecraft returning from the Moon. The success of the mission, including Orion's atmospheric reentry and recovery, provides an opportunity to revitalize an integrated robotic and human exploration program to the Moon and beyond.

Exploration of the Moon will address fundamentally important scientific questions, according to a broad international consensus of scientists [e.g., *National Research Council* (NRC), 2007], while also providing a credible path to carry humanity beyond low-Earth orbit [e.g., *International Space Exploration Coordination Group* (ISECG), 2013]. Toward that goal of renewed lunar exploration, scientists have accumulated new insights from a new generation of robotic spacecraft sent to the Moon. These spacecraft include the United States's Clementine, Lunar Prospector, Lunar Reconnaissance Orbiter, Gravity Recovery and Interior Laboratory (GRAIL), and Lunar Atmosphere and Dust Environment Explorer (LADEE); Europe's Small Missions for Advanced Research in Technology (SMART-1); China's Chang'e series of orbiters; Japan's Kaguya; and India's Chandrayaan-1.

Orbital spacecraft, supplementing the insights from Apollo and the missions before it, indicate the Moon is the best and most accessible place to evaluate the origin and evolution of the entire solar system. This evaluation could include new insights on the earliest evolutionary phases of our own planet, which through plate tectonics, crustal recycling, and constant weathering, have since been erased from Earth's rock record.

The Moon contains evidence of how it formed through accretion and differentiated into layers of crust, mantle, and core, which is a model for the origin and evolution of other solar system planets. It also records the history of asteroid and comet impacts on that crust, which is essential to evaluating the environmental and biological consequences of such events, both on Earth and on other potentially habitable worlds such as Mars.

Target: South Pole–Aitken Basin?

A 2007 report from the U.S. National Research Council—one of the most comprehensive studies of lunar exploration objectives—outlined 35 prioritized investigations. A global landing site study [*Kring and Durda,* 2012] concluded that the majority of the objectives could be addressed in the Moon's South Pole–Aitken basin.

At 2500 kilometers across, South Pole–Aitken is one of the largest impact basins in the solar system. Within it, the 320-kilometer-wide Schrödinger basin holds the most promise for finding scientific pay dirt. A sample return mission to Schrödinger has the potential to address the two highest science priorities from the *NRC* [2007] report. First, it could determine the length of the basin-forming epoch—the geological period in the Moon's early history when objects that formed enormous basins like South Pole–Aitken smashed to the surface. Second, samples from Schrödinger could help determine the age of South Pole–Aitken.

In addition, because the basin is so well preserved, it is a perfect target for discerning the geological processes of such impacts. Those processes also uplifted material from great depth, producing a ring of crystalline massifs. These exposed layers of rock may date back to when, according to a prevailing hypothesis, the Moon was covered by a magma ocean (before South Pole–Aitken formed).

That material, when combined with material exposed in the basin walls, can be used to reconstruct a cross section of the lunar crust. The melted rock on the floor of Schrödinger basin can be used to derive the bulk composition of that crust.

Scientists think that long after the impact melt solidified, magmas rose through the basin and erupted on its floor, producing mare basalt flows and an immense vent spewing hot rock and gas. The basalt and pyroclastic vent can also be used to probe the thermal evolution of the lunar interior. The

New lunar landers have yet to be designed, meaning that the world no longer has the capability to land crew on the Moon's surface. To accomplish sound science without this capacity, researchers are seeking to combine robotic and human capabilities.

pyroclastic vent may also yield deposits of volatiles (such as sulfur and water) and fine-grained material that can easily be excavated, transported, and processed for use on the Moon to support a sustainable exploration effort.

Toward Sample Return Missions

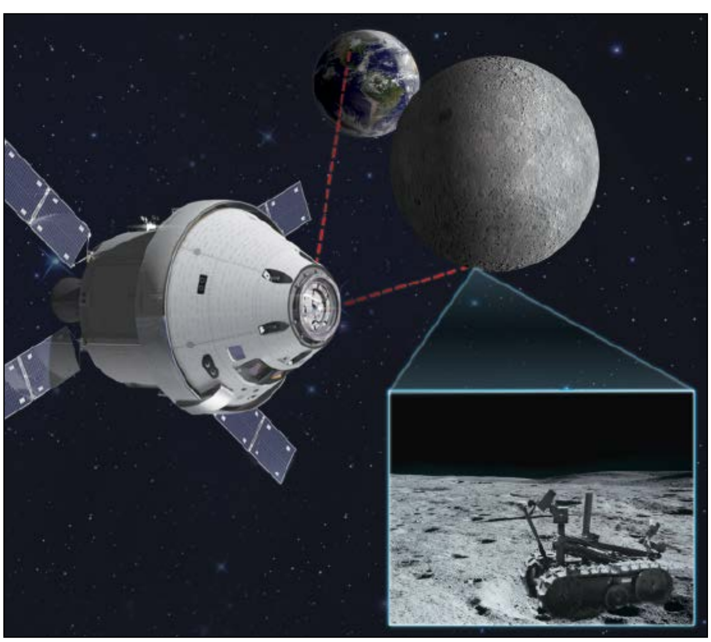
To adequately address the *NRC* [2007] lunar objectives, sample return missions are required. The best results and those that maximize the advantages of an integrated robotic and human exploration program would be obtained by a trained crew on the lunar surface.

In pursuit of that type of integrated program, robotic efforts from many nations are under way. China recently landed a robotic spacecraft in Mare Imbrium as a precursor to a human landing scheduled for 2025–2030. Russia is planning a series of five robotic spacecraft, including a sample return mission that may involve the European Space Agency. Those efforts are part of an international community road map [*ISECG*, 2013] that includes a human-assisted robotic sample return mission circa 2024 and a human lunar surface mission circa 2028.

Unfortunately, new lunar landers have yet to be designed, meaning that the world no longer has the capability to land crew on the Moon's surface. To accomplish sound science without this capacity, researchers are developing plans for an alternative (and hopefully interim) solution combining robotic and human capabilities.

A Robotic Moon Lander Complemented by a Hovering Orion?

Burns et al. [2013] outlined a plan to deploy robotic vehicles—a Moon lander—to Schrödinger basin that could be operated remotely by a crew in the Orion spacecraft. In this plan, Orion would hover above the Moon's farside around Earth–Moon Lagrange position L2.



LPI/David A. Kring

In a concept using NASA's new Orion crew vehicle, astronauts would orbit above the lunar farside and remotely operate a robotic vehicle while maintaining communication with Earth. Samples collected by a rover would be launched to Orion, where they would be stowed before the crew returned to Earth.

Candidate landing sites with traverses, along which a rover would collect samples and return them to the ascent vehicle, have already been identified [*Potts et al.*, 2015]. This vehicle would then rendezvous with Orion so that crew could return the samples to Earth.

This mission would present technical challenges that scientists and engineers will need to solve as part of the redevelopment and expansion of capabilities to explore beyond low-Earth orbit. It would also demonstrate Orion's capabilities to conduct long-duration operations, traveling 15% farther than Apollo and spending 3 times longer in deep space. It would practice teleoperation of rovers, which is an anticipated skill for future missions to Mars. It would also simultaneously address a majority of the *NRC* [2007] science objectives.

This mission or a similar one could deploy an astrophysical observatory, another high-priority *NRC* [2010] objective, and a communications satellite for future robotic and human missions. Joint scientific and engineering studies continue with the hope that this integrated robotic and human mission will be the first of many milestones that enhance our ability to explore space.

Acknowledgments

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Increasing Diversity in the Geosciences

By Jacqueline E. Huntoon, Courtney Tanenbaum, and Jill Hodges

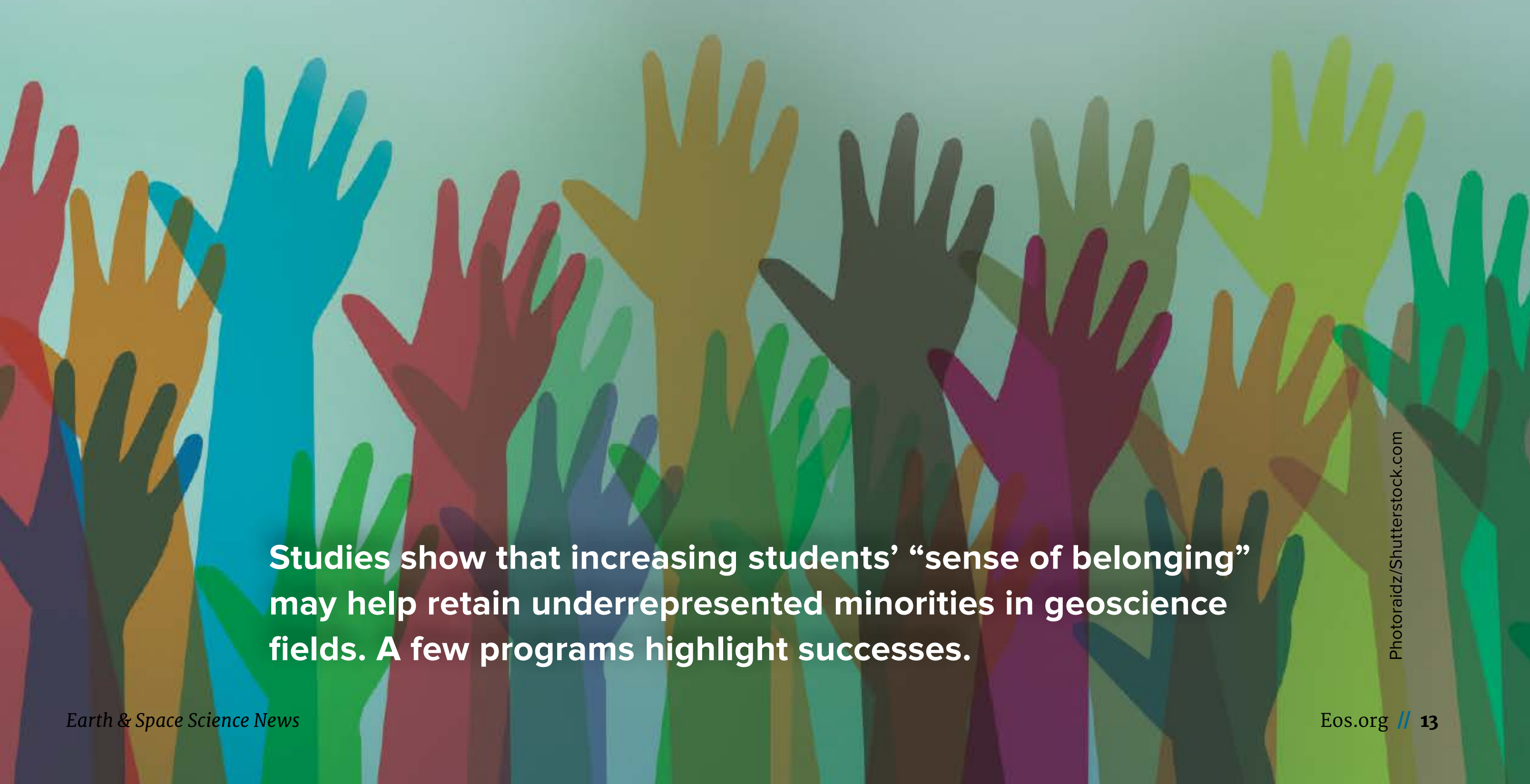
Similar to many science, technology, engineering, and mathematics (STEM) disciplines, the geosciences suffer from a lack of racial and ethnic diversity, particularly at doctoral levels and within academia. Unfortunately, the geosciences have the lowest diversity of all the STEM fields at all levels of higher education [*National Center for Science and Engineering Statistics,* 2015].

To increase the capacity of institutions of higher education to prepare domestic underrepresented minority students for academic positions in STEM, the National Science Foundation (NSF) created the Alliances for Graduate Education and the Professoriate (AGEP) grant program. Through AGEP grants, studies have identified factors that reduce the likelihood that underrepresented minority students will complete a Ph.D. and pursue an academic career in STEM.

Emerging research focuses on ways to mitigate those factors, enhance underrepresented minorities' persistence in doctoral programs, and increase their interest and success in academic careers. Increasing students' sense of belonging in STEM appears to be a particularly promising strategy for enhancing diversity.

Facing Stereotype Threat and Imposter Syndrome

Two general categories of factors disproportionately and negatively impact underrepresented minority students: stereotype threat and



Studies show that increasing students' "sense of belonging" may help retain underrepresented minorities in geoscience fields. A few programs highlight successes.

Photoraidz/Shutterstock.com

Even though group-wide generalizations normally prove false for specific individuals, they still influence how people see themselves and can have negative impacts.

imposter syndrome. Both adversely affect students' persistence and career aspirations in STEM.

"Stereotype threat" is a term used to describe the concept of some people being good or not good at something simply because they self-identify as a member of a group for which a stereotype of ability applies. Even though group-wide generalizations normally prove false for specific individuals, they still influence how people see themselves and can have negative impacts. For example, a common misperception holds that women are not good at math; identifying with this stereotype can, in and of itself, affect women's performance in math [*Spencer,* 1999].

Research shows that the impact of stereotype threat is most pronounced among people who care deeply about how well they will do on a traditional test or another type of assessment [*Steele and Aronson,* 1995; *Steele,* 2003]. This outcome is logical because people who are extremely concerned about their performance are likely to expend mental energy worrying about whether their potential for success is intrinsically limited. Additional research shows that the act of worrying about one's performance, even subconsciously, results in cognitive load that reduces performance [*Steele,* 2010].

Any doubts that stereotype threat is a real phenomenon can be allayed by *Frontline*'s "A Class Divided" [*Peters,* 1985], which shows the impact of stereotypes on behavior and performance. The segment chronicles an exercise in which teacher Jane Elliot divided her all-white third-grade class into two groups based on eye color. On one day the brown-eyed children were told that they were inferior, were required to wear collars, and were constantly criticized, whereas the blue-eyed children were praised and given special privileges. Subsequently, the roles of the two groups were reversed. In both cases, the "inferior" group performed poorly on assessments, and the "superior" group behaved maliciously. Elliot's exercise has been repeated many times, with the same outcomes.

"Imposter syndrome" describes the sense of feeling not "good enough" to be a member of a particular community. People who are affected by imposter syndrome often fear that others will discover that they are undeserving of their position and expose them as imposters, which will cause them to lose their status [*Young,* 2011]. Feelings of being an imposter can result in diminished self-efficacy, increased cognitive load, and decreased performance.

People suffering from imposter syndrome also have difficulty accepting and internalizing evidence of their own competence and intelligence. Even people who appear to be highly successful by all outward measures can suffer from imposter syndrome; these individuals suspect that their achievements are the result of luck or accident rather than their own talent and actions.

Imposter syndrome may affect some individuals more than others, particularly those who are in the minority or who lack role models. For example, if no Native American faculty are in a geology department, a Native American student might feel that the goal of becoming a geology professor is unattainable. Even if the student eventually becomes a faculty member, this sense of being an imposter might continue.

A TED talk by social psychologist Amy Cuddy explains how nonverbal expressions of power and dominance influence how we think and feel about ourselves as well as how others see us. The popularity of this talk, viewed by more than 23 million people and translated into 40 languages, suggests that many people strive to overcome the feeling that they are imposters [*Cuddy,* 2012].

Seeking Support: Friends and Mentors

Research shows that the effects of stereotype threat and imposter syndrome can be mitigated by increasing students' sense of belonging [*Walton and Cohen,* 2007]. Sense of belonging is characterized by feeling welcomed, recognized, included, and appreciated. The feeling is fostered by trust, supportive relationships, and cross-group and cross-cultural dialogues about belonging in a specific setting [*Steele,* 2010].

Having a sense of belonging not only mitigates experiences of stereotype threat and imposter syndrome but is also conducive to learning. One set of brain circuitry is used for thinking about those whom we perceive as similar to ourselves ("friends"), whereas a different set is used for thinking about those whom we view as different ("foes"). When we feel comfortable with someone (a member of the friend category), we experience a positive emotional response that allows us to be more open to and speak freely about new ideas. This openness increases the speed of learning and the ability to apply learning to new and different situations [*Rock,* 2009].

Examples of Strong Mentoring Programs

Strong mentoring programs and vibrant intellectual communities increase students' sense of belonging [*Wilson and Linville,* 1982; *Good et al.,* 2012]. For example, Minorities Striving and Pursuing Higher Degrees of Success (MS PHD'S; http://www.msphds.org) and the National GEM Consortium (http://www.gemfellowship.org) connect graduate students and professionals from underrepresented minority groups across the nation to provide students with access to supportive mentors. These organizations build underrepresented minority students' sense of belonging by providing them with opportunities to develop their own professional network [*Johnson and Lucero,* 2003; *Pyrtle and Williamson Whitney,* 2008].

The Michigan AGEP Alliance (http://michagep.org), currently under way at five research universities in Michigan, promotes STEM students' sense of belonging by engaging students and faculty in campus-based interdisciplinary learning communities and mentoring programs. Together, the learning communities and mentoring programs provide

When we feel comfortable with someone, we experience a positive emotional response that allows us to be more open to and speak freely about new ideas.

participants with opportunities to share experiences and strategies for academic success in a supportive setting.

The Fisk-Vanderbilt Master's-to-PhD Bridge Program [*Stassun et al.,* 2011; see http://www.vanderbilt.edu/gradschool/bridge/] provides another model for mentoring underrepresented minorities and building their sense of belonging and self-efficacy in a supportive yet challenging environment. One lesson learned by the Fisk-Vanderbilt team is the importance of "making the implicit explicit" [*Stassun,* 2013]. Expectations in academia need to be clearly identified and explained so that students who are not inherently familiar with academic culture and processes can be prepared to meet the challenges they will face.

Increasing Diversity for the Benefit of All

The programs described above, along with many others, help underrepresented minority students earn graduate degrees and pursue academic careers in STEM. Mounting evidence shows that efforts to attract and retain diverse students are enhanced when successful professionals promote students' sense of belonging by recognizing potential, encouraging aspiration, and providing accurate information to students about how to achieve their academic goals.

Indications of the inherent benefits of diversity are also growing [*Page,* 2008]. A diverse academic workforce will be better prepared to understand and respond to the needs of society by offering a wider array of perspectives and innovative approaches to solving national and global challenges. Thus, increasing diversity in academia may ultimately benefit us all.

J. E. Huntoon

Graduate students at Michigan Technological University involved with the Michigan AGEP Alliance interdisciplinary learning community. AGEP stands for Alliances for Graduate Education and the Professoriate.

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Climate Science Day on Capitol Hill Connects Scientists and Policy Makers

Haley Fulford

Participants meet with Congressman Sanford Bishop (D-Ga.). (left to right) Kim Cobb, Rep. Bishop, Matt Sitkowski, and Lily Strelich.

On 10–11 February, 23 scientists from 13 states traveled to Washington, D. C., to build relationships with members of Congress and explain the importance of climate science research.

The political landscape could not have been better for the fifth annual Climate Science Day: A recent Pentagon report cited climate change as a major threat to national security. In his State of the Union speech, President Barack Obama declared that "no challenge poses a greater threat to future generations than climate change." In January, the Senate voted 98–1 that climate change is not a hoax.

AGU jointly hosted the event with nine other Earth and space science organizations. The event included a half-day training session on how best to communicate with Congress members and staff. Participants also heard from a panel of current AGU Congressional Science Fellows and worked in groups to practice how to effectively communicate key messages.

Participants collectively attended a total of 88 meetings with Congress members, their staff, and select congressional committees. These conversations were an opportunity for scientists to share information about their research with their district representatives and with others. Through these conversations, they underscored the importance of climate science in supporting economic growth and national security. Ongoing climate science research is a crucial component of mitigating extreme weather events, rising sea levels, and other consequences of rising global temperatures, and these meetings gave participants a chance to demonstrate how federal support and funding for climate science help to protect American jobs, infrastructure, and public health and safety.

These conversations, which facilitate and strengthen mutually beneficial relationships, are a vital component of AGU's efforts to bridge the gap between legislators and professional scientists. One of the great strengths of Climate Science Day is simply demonstrating that scientists are prepared to invest in science policy issues and share their expertise with policy makers.

One Senate staffer thanked participants with some advice to her colleagues: "Don't just know the right answer; know the expert." By reaching out to their representatives, Climate Science Day participants established themselves as a valuable resource for those responsible for crafting federal science policy.

Climate Science Day is one of several AGU programs that promote the importance of science on Capitol Hill and connects scientists with their representatives. AGU and partner organizations also host briefings, exhibitions, and additional Congressional Visits Days (http://sciencepolicy.agu.org/cvd/). These include Science-Engineering-Technology Congressional Visits Day on 17–18 March 2015 and Geoscience Congressional Visits Day in late September (dates to be announced).

For more information on AGU congressional events, visit AGU's science policy website (http://sciencepolicy.agu.org/events/). To find out how you can get involved, please email sciencepolicy@agu.org.

AGU thanks the following members for participating in the 2015 Climate Science Day:

Jonathon Overpeck, University of Arizona
Michael Stein, University of Chicago
Jan Hopmans, University of California, Davis
Leonard Smith, London School of Economics
James Elsner, Florida State University
Kim Cobb, Georgia Institute of Technology
Matt Sitkowski, The Weather Channel
Matt Huber, University of New Hampshire
Carol Anne Clayson, Woods Hole Oceanographic Institute
Peter DeCarlo, Drexel University
Douglas Ray, Pacific Northwest National Laboratory

By **Lily Strelich,** Public Affairs Intern, AGU; email: lstrelich@agu.org

Task Force Recommends Ways to Improve AGU Fellows Program

When the first class of Fellows was elected in 1962, AGU was a very different organization than it is today. The percentage of members from outside the United States nearly doubled from 1975 to 2014 and has grown from 32% to 39% during the past 14 years. In addition, the percentage of women members has grown from 15% to 22% since the year 2000. Cross-disciplinary and interdisciplinary science has also grown, as noted in the recent AGU Scientific Trends Report (http://bit.ly/AGUSciTrends).

Recognizing the impact and importance of these changes, AGU established a task force in October 2013 to review the Fellows program. The task force was charged with reviewing the current AGU Fellows selection process and making recommendations for any potential changes that might improve perceived gaps in the selection of interdisciplinary scientists, women, or candidates from other underrepresented groups while maintaining the current prestige of the Fellows program.

AGU membership has grown more diverse in the last 50 years, and the prevalence of interdisciplinary science has grown significantly," said Rana Fine, chair of the AGU Fellows Program Review Task Force. She is an AGU Board member and past chair of the AGU Honors and Recognition Committee. "Because the AGU Fellows program is so important to the membership and because it holds such prestige and regard within the worldwide Earth and space science community, the leadership of AGU considered it both timely and wise to review the program's performance and operations to ensure that its legacy remains as meaningful 50 years from now as it does today."

The results of this yearlong assessment were recently published in a comprehensive report that outlines a series of findings and recommendations for improving the Fellows program.

Task Force Recommendations

The task force made the following recommendations:

Communicate Best Practices: The AGU Honors and Recognition Committee should aggressively communicate best practices and guidelines for encouraging and supporting more diverse Fellows nominations. These best practices include establishing section and focus group canvassing committees to help broaden the candidate pool, promoting diversity in ranking and selection committee membership, training committees on how to avoid implicit bias, and capturing institutional memory from past leaders of ranking and selection committees.

Revise Fellows Selection Criteria: AGU should update and revise its criteria for selecting AGU Fellows to more explicitly recognize a home for

scientists working in emerging interdisciplinary, transdisciplinary, or cross-disciplinary scientific areas. AGU should also remove current wording such as “paradigm shift”—this wording is loosely defined and describes something that often cannot be recognized until long after it happens.

The new criteria for evaluating scientific eminence are

- breakthrough or discovery
- innovation in disciplinary science, cross-disciplinary science, instrument development, or methods development; and/or
- sustained scientific impact

Track and Report Diversity Performance: AGU should continue to collect data on diversity performance and distribute this data to members of canvassing and ranking committees. Transparency would be increased by publishing these demographics in *Eos* each year.

Provide Explicit Instruction and Caution on the Use of h-Index: The h-index—a measurement used to describe scientific productivity based on the number of papers written and the number of times those papers have been cited—should no longer be required as part of a nomination package. Guidelines for nominations should state that when the h-index is used, it is meant to be compared only within a scientific discipline. When used in a nomination package or mentioned in recommendation letters, it would be incumbent on the writer to include the source of the h-index and a URL that has been uniquely identified for the candidate’s h-index calculation.

Adopt a Consistent Policy of No Hold-Over Nominations: AGU’s Union Fellows Selection Committee should adopt a consistent practice of no hold-over nominations. In the past, some nomination packages were designated to automatically be considered the following year without being resubmitted. Going forward, sections and focus groups should solicit updated packages for all nominations and provide feedback from the Union Fellows Selection Committee to the nominator.

> Recommendation: The h-index—a measurement used to describe scientific productivity based on the number of papers written and the number of times those papers have been cited—should no longer be required as part of a nomination package.

Establish an AGU “College of Fellows”: The AGU Honors and Recognition Committee should explore the concept of a College of Fellows, whose members could contribute to activities such as outreach, education, mentoring, shadowing, the development of position statements, and fundraising.

Continue Research on Diversity and Interdisciplinary Representation and Possible Interventions: Some recent trends—particularly the growing diversity of Earth and space scientists, AGU membership, and recipients of AGU honors and recognition—merit further study. The impacts of implementing the recommendations of this report will also require follow-up study to evaluate their effectiveness. The task force recommends that AGU continue to explore these issues further, perhaps as part of a follow-on effort to evaluate the effectiveness of the specific recommendations from this report that are adopted.

Approval by the Council

The task force’s recommendations, and associated background data and discussion, are included in the report, which was presented to the AGU Council in December 2014 and which is now available to the public. The report includes extensive demographic data along with discussions on related topics, such as the criteria for selecting Fellows, diversity considerations, details of the limitations of the h-index, and opportunities for increased engagement with AGU Fellows.

“The task force presented its recommendations to the AGU Council in December 2014, urging that they be pursued and adopted as soon as practical. The Council approved all the key recommendations, and I’m pleased to say that much of this work is now under way, including the development of a strategy for those recommendations that require further research on AGU’s part,” said Samuel Mukasa, AGU’s 2015–2016 Honors and Recognition Committee chair.

The task force’s report and additional information about the project are available online at http://bit.ly/AGUFellowsReview.

AGU Fellows Program Review Task Force Members

Kelly Caylor, Princeton University, Princeton, N.J.
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Carle Pieters, Brown University, Providence, R.I. (ex-officio, 2013–2014 Union Fellows Selection Committee Chair)
Carol Raymond, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.
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Alan Robock, Rutgers University, New Brunswick, N.J.
Dominique Weis, University of British Columbia, Vancouver, BC, Canada
Don Wuebbles, University of Illinois, Urbana, Ill.

By **Billy M. Williams,** Science Director, AGU, Washington, D.C.; email: bwilliams@agu.org

Outstanding Student Paper Awards

The following AGU members received Outstanding Student Paper Awards at the 2014 AGU Fall Meeting in San Francisco, Calif. Winners have individual pages on AGU's website at http://membership.agu.org/ospa-winners/.

Atmospheric and Space Electricity

Coordinators: Xianan Jiang, Jianjun Liu, Brant Carlson, Tao Wang, Morris Cohen

Rasoul Kabirzadeh, Stanford University, *Multi-scale 3D simulation of lightning and thunderstorm electrodynamics*

David Sarria, University Paul Sabatier Toulouse III, *Some spatial and temporal properties of secondary electrons and positrons produced by terrestrial gamma-ray flashes derived from Monte-Carlo simulations*

Atmospheric Sciences

Coordinators: Yolanda Roberts, Sue Chen, Shannon Capps, Yongyun Hu

Elizabeth Maroon, University of Washington, *The influence of a single Northern Hemisphere continent on tropical precipitation and climate in idealized GCM experiments*

Abigail R. Koss, University of Colorado at Boulder, *Derived emission rates and photochemical production rates of volatile organic compounds (VOCs) associated with oil and natural gas operations in the Uintah Basin, UT during a wintertime ozone formation event*

Rachel Schwartz, University of California, San Diego, *North American west coast summer low cloudiness: Broadscale variability associated with sea surface temperature*

Peer Johannes Nowack, University of Cambridge, *A large ozone-circulation feedback and its implications for global warming assessments*

Maria Rugenstein, Swiss Federal Institute of Technology (ETH) Zurich, *The ocean is shaping tropospheric adjustments*

Forest Cannon, University of California, Santa Barbara, *Winter westerly disturbance activity in High Mountain Asia: A wave tracking approach*

Gregory P. Schill, University of Colorado at Boulder, *Heterogeneous ice nucleation on simulated sea-spray aerosol using Raman microscopy*

Mary Cameron, Stanford University, *Quantifying the spatial and temporal distribution of aircraft emissions in the upper-troposphere/lower stratosphere*

Chelsea Preble, University of California, Berkeley, *N_2O and NO_2 emissions from heavy-duty diesel trucks with advanced emission controls*

Philippe Papin, State University of New York at Albany, *Tropical cyclone interactions within Central American gyres*

Kristen Rasmussen, University of Washington, *Convective initiation in the vicinity of the subtropical Andes*

Geeta Persad, Princeton University, *Similarities in the spatial pattern of the surface flux response to present-day greenhouse gases and aerosols*

Manuel Helbig, University of Montreal, *Seasonal dynamics of the land surface energy balance of a boreal forest-peatland landscape affected by degrading permafrost in the Taiga Plains, Canada*

Alejandra Borunda, Columbia University in the City of New York, *Local sources for the "megadust" events at the WAIS Divide ice core*

Marco Giometto, Swiss Federal Institute of Technology Lausanne (EPFL), *The impact of variable building height on drag, flow and turbulence over a realistic suburban surface*

Sarah Connors, University of Cambridge, *A41N-05: High-resolution methane emission estimates using the InTEM inversion system*

Daniel Anderson, University of Maryland, College Park, *Determination of stratospheric and anthropogenic contributions to enhanced mid-tropospheric O_3 in the tropical western Pacific*

Eric Lebel, Providence College, *Dimethyl sulfide emissions from dairies and agriculture as a potential contributor to sulfate aerosols in the California Central Valley*

Biogeosciences

Coordinators: Guofang Miao, Yiran Dong, Melanie Harrison, Feng Zhou, Susan Natali, Jasmine Crumsey

Dylan Meyer, University of Texas at Austin, *Vertical migration of gas through fracture due to salinity-buffered hydrate formation within the hydrate stability zone*

Justine Sauvage, University of Rhode Island, *Boosting subsurface life: Is subseafloor sediment a natural catalyst for radiolytic hydrogen production?*

Lucy Stewart, University of Massachusetts Amherst, *Reactive transport model of growth and methane production by high-temperature methanogens in hydrothermal regions of the subseafloor*

Eleanor Campbell, Colorado State University, *The Litter Decomposition and Leaching (LIDEL) model: Modeling plant litter decomposition to CO_2, dissolved organic matter and microbial products through nitrogen and lignin controls on microbial carbon use efficiency*

Jessica Corman, Arizona State University, *Growing rocks: Implications of lithification for microbial communities and nutrient cycling*

Olivia Stoken, University of Virginia, *Association of dissolved mercury with dissolved organic carbon in rivers and streams: The role of watershed soil organic carbon*

Mike Alonzo, University of California, Santa Barbara, *Mapping urban forest leaf area index using lidar: A comparison of gap fraction inversion and allometric methods*

Susan Meerdink, University of California, Santa Barbara, *Linking seasonal foliar chemistry to VSWIR-TIR spectroscopy across California ecosystems*

Erin C. Seybold, Duke University, *Carbon metabolism, uptake kinetics, and export: How watershed form influences carbon mobilization and in-stream transformations in headwater catchments*

Rose Smith, University of Maryland, College Park, *Export and metabolism of carbon in urban watersheds: Climate Implications*

Cryosphere

Coordinators: Eric Sproles, Martin O'Leary, Ru Chen

Fernando Serrano Paolo, University of California, San Diego, *Complex Antarctic ice shelf thickness changes revealed by eighteen years of satellite radar altimetry*

Kelly E. Gleason, Oregon State University, *Charred forests increase snow albedo decay: Watershed-scale implications of the postfire snow albedo effect*

Vena W. Chu, University of California, Los Angeles, *Remote estimation of Greenland ice sheet supraglacial river discharge using GIS modeling and WorldView-2 satellite imagery*

Alicia M. Rutledge, Arizona State University, *Mapping glacial weathering processes with thermal infrared remote sensing: A case study at Robertson Glacier, Canada*

Logan C. Byers, University of Kansas, *Processing time-series point clouds to reveal strain conditions of the Helheim Glacier terminus and its adjacent mélange*

David Shean, University of Washington, *Amundsen Sea sector ice shelf thickness, melt rates, and inland response from annual high-resolution DEM mosaics*

Joanna Young, University of Alaska Fairbanks, *Spatially distributing a GRACE mascon solution across Gulf of Alaska glaciers*

Melissa Gervais, McGill University, *The evolution of Arctic air masses in a warming world*

Earth and Planetary Surface Processes

Coordinators: Ken Ferrier, Leslie Hsu

Mathieu Lapotre, California Institute of Technology, *Hydraulic reconstructions of outburst floods on Earth and Mars*

Kurt Imhoff, University of Montana, *Sediment routing through channel confluences: RFID tracer experiments from a gravel-bed river headwaters*

Eric Winchell, University of Colorado at Boulder, *Infilled tunnels, mounds, and stonelines: Evidence of the annual to centennial impacts of gophers in the montane meadows of Colorado's Front Range*

Dan Scott, Colorado State University, *Physical controls on delta formation and carbon storage in mountain lakes*

Derek Schook, Colorado State University, *Using cottonwood dendrochronology to reconstruct river discharge and floodplain dynamics, Yellowstone River, Montana*

Jessica A. Zinger, University of Illinois at Urbana-Champaign, *Flow, morphology and sedimentology of an evolving chute cutoff on the Wabash River, IL-IN*

Sharon Bywater-Reyes, University of Montana, *Sensitivity analysis of vegetation-induced flow steering in channels*

Earth and Space Science Informatics

Coordinators: Jichun Zhang, Alfred Kalyanapu, Xiaogang Ma

Chung-Yi Hou, University of Illinois at Urbana-Champaign, *Discovering new global climate patterns: Curating a 21-year high temporal (hourly) and spatial (40km) resolution reanalysis dataset*

Christopher Kadow, Free University of Berlin, *A hybrid evaluation system framework (Shell & Web) with standardized access to climate model data and verification tools for a clear climate science infrastructure on big data high performance computers*

Education

Coordinators: David Lagomasino, Stacie Bender

Kathryn Materna, University of California, Berkeley, *Analysis of atmospheric delays and asymmetric positioning errors in GPS*

Geodesy

Coordinators: Gareth Funning, Arun Kumar, Emily Montgomery-Brown, Xiaopen Tong

Heming Liao, University of Alaska Fairbanks, *Ionosphere effect correction in InSAR using improved split spectrum processing*

Keven Roy, University of Toronto, *Mantle viscosity constraints from U.S. East Coast relative sea level histories: Implications for understanding the glacial isostatic adjustment of the North American continent*

Lambert Caron, Institut de Physique du Globe de Paris, *Inverting glacial isostatic adjustment beyond linear viscoelasticity using Burgers rheology*

Geomagnetism and Paleomagnetism

Coordinators: Gunther Kletetschka, Michael Purucker, Laurie Brown, Ken Kodama

Livia Kother, Technical University of Denmark, *An equivalent source method for modelling the lithospheric magnetic field using satellite and airborne magnetic data*

Elisa Piispa, Michigan Technological University, *Paleomagnetism of the ~1.1 Ga Baraga-Marquette dykes (Michigan, USA)*

Global Environmental Change

Coordinators: Sarah Green, Afshin Pourmokhtarian, David Noone

Ruth Heindel, Dartmouth College, *Phosphorus cycling in an extreme environment: Grain-scale investigation of apatite weathering in the McMurdo Dry Valleys, Antarctica*

Miriam Gonzalez, University of Hamburg, *Ocean-based alkalinity enhancement: Mitigation potential, side effects and the fate of added alkalinity assessed in an Earth system model*

Michael Glotter, University of Chicago, *Evaluating the reliability of reanalysis as a substitute for observational data in large-scale agricultural assessments*

David Mildrexler, Oregon State University, *Characterizing an integrated annual global measure of the Earth's maximum land surfacetTemperatures from 2003 to 2012 reveals strong biogeographic influences*

Hydrology

Coordinators: Terri Hogue, Kolja Rotzoll, Laurel Saito, Newsha Ajami, Tara Troy

Camille Ouellet Dallaire, McGill University, *River reach classification for the Greater Mekong Region at high spatial resolution*

Adam Wlostowski, Colorado State University, *How do hyporheic zones mediate stream solute loads? Using Antarctic glacial melt streams to simplify the problem*

Matthew Kaufman, University of Texas at Austin, *Transport of solutes in hyporheic zones with temperature-dependent reversible sorption*

Zachary Hoylman, University of Montana, *Landscape heterogeneity modulates forest sensitivity to climate*

Jane Yuen Yung Chui, Massachusetts Institute of Technology, *Interface evolution during radial miscible viscous fingering*

Catherine Finkenbiner, University of Nebraska–Lincoln, *Improving the operability of the cosmic-ray neutron soil moisture method: Estimation of soil calibration parameters using global datasets*

Kevin Befus, University of Texas at Austin, *Estimating the distribution of contemporary (<50 year old) groundwater on Earth*

Jaylee Conlin, Arizona State University, *Identification and atmospheric transport of microcystin around Southern California using airborne remote sensing*

Maura Allaire, University of North Carolina at Chapel Hill, *The hydromorphology of an urbanizing watershed using multivariate elasticity*

Anna Bergstrom, University of Montana, *Incorporating landscape heterogeneity to understand patterns of stream discharge across spatial and temporal scales in forested mountain watersheds*

Joaquim Soler Sagarra, Polytechnic University of Catalonia, *Reactive transport modelling by using Eulerian-Lagrangian methods based on mixing*

Laureline Josset, University of Lausanne, *Functional error models to accelerate nested sampling*

Adrien Selles, Université Pierre et Marie Curie, *Temperature as tracer of the groundwater circulation within a complex volcano-detritic system*

Kimberly Manago, Colorado School of Mines, *Multiple imputation of groundwater data to evaluate spatial and temporal anthropogenic influences on subsurface water fluxes in Los Angeles, CA*

Ashley Michelle Matheny, Ohio State University, *Proposed hydrodynamic model increases the ability of land-surface models to capture intra-daily dynamics of transpiration and canopy structure effects*

Mineral and Rock Physics

Coordinators: Congrui Jin, Wendy Panero

Kevin J. Miller, University of Maryland, College Park, *Electrical conductivity and permeability of partially molten mantle rocks: Results from digital rock physics experiments*

Alisha Clark, University of California, Davis, *Volumetric and elastic properties of basalt at high pressure by X-ray microtomography and GHz-ultrasonic interferometry*

Natural Hazards

Coordinators: Celso Ferreira, Peter Webley, Zhenhong Li

Kasey Schultz, University of California, Davis, *Virtual California: Earthquake statistics, surface deformation patterns, surface gravity changes and InSAR interferograms for arbitrary fault geometries*

Yuki Nakashima, Hokkaido University, *Ionospheric disturbances by volcanic eruptions by GNSS-TEC: Comparison between Vulcanian and Plinian eruptions*

Near Surface Geophysics

Coordinators: Fred Day-Lewis, John Lane, Xavier Comas

Emily Wei, University of California, San Diego, *Clinothem lobe growth and possible ties to downslope processes in the Gulf of Papua*

Chelsea Lancelle, University of Wisconsin–Madison, *Directivity and sensitivity of fiber-optic cable measuring ground motion using a distributed acoustic sensing array*

Gerrit Olivier, University Joseph Fourier Grenoble, *Noise-based body-wave seismic tomography in an active underground mine*

Ocean Sciences

Coordinators: Robert Mason, Gregory Cutter, Deborah Hutchinson, Silvia Gremes-Cordero

Johanna Press, Yale University, *Modeling trace element concentrations in the San Francisco Bay estuary from remote measurement of suspended solids*

Jörn Callies, Massachusetts Institute of Technology, *Wave-vortex decomposition of one-dimensional ship track data*

Marta Ribo, Polytechnic University of Catalonia, *Large-scale fine-grained sediment waves over the Gulf of Valencia continental slope (northwestern Mediterranean Sea)*

Ryan M. Holmes, Stanford University, *The vortex dynamics of tropical instability waves and their impacts on equatorial mixing in a regional ocean model*

Paleoceanography and Paleoclimatology

Coordinators: Arghy Goswami, Jessica Carilli

Rosie Oakes, Pennsylvania State University, *Adding a new dimension to the study of calcareous plankton response to ocean acidification*

Kevin Burke, University of Wisconsin–Madison, *Improving estimates of regional vegetation: Using pre-settlement vegetation data and variable wind speed to quantify pollen dispersal and source area*

Madelyn Mette, Iowa State University, *Linking North Atlantic climate dynamics with shell growth and geochemistry in northern Norway*

Planetary Sciences

Coordinators: Douglas Galante, Lindy Elkins-Tanton, Nathan Bridges

Anna Grau Galofre, University of British Columbia, *A quantitative characterization and classification of Martian Valley networks: New constraints on Mars' early climate and its variability in space and time*

Tajana Schneiderman, Ohio State University, *Adaptive multi-sensor data fusion model for in-situ exploration of Mars*

Catherine Elder, University of Arizona, *Convection and melt migration in Io's mantle*

Jason Hofgartner, Cornell University, *Specular reflections from Titan's equatorial region: Solving the decade old mystery*

James Keane, University of Arizona, *The contribution of impact basins and mascons to the lunar figure: Evidence for lunar true polar wander, and a past low-eccentricity, synchronous lunar orbit*

Public Affairs

Coordinators: Denise Hills, Linda Rowan, Shengqian Chen

John Kotcher, George Mason University, *Scientists as communicators: A randomized experiment to assess public reactions to scientists' social media communication along the science-advocacy continuum*

Seismology

Coordinators: Bateer Wu, Hao Zhang, Richard Allen, Zuoxun Zeng

Kevin Seats, Stanford University, *Spatially locating time-lapsed relative velocity changes in Yellowstone*

Amy Williamson, Georgia Institute of Technology, *Temporal feasibility of rapid joint inversions in response to tsunamis triggered by megathrust earthquakes*

Daniel Bowden, California Institute of Technology, *Ambient noise correlation amplitudes and local site response*

Saulė Žukauskaitė, Swiss Federal Institute of Technology (ETH) Zurich, *Full seismic waveform inversion for the Japanese islands*

Martin Gal, University of Tasmania, *Frequency dependence of short period seismic noise from two decades of observations at Warramunga Seismic Array (WRA), Australia*

Jennifer Neale, University of Southampton, *Infragravity wave generation and reflection off the coast at Oregon, USA*

Avinash Nayak, University of California, Berkeley, *Investigation of seismic events associated with the sinkhole at Napoleonville Salt Dome, Louisiana*

Rhys Hawkins, Australian National University, *A multi-scale framework for trans-dimensional tomography*

Stephen Perry, California Institute of Technology, *Towards reconciling magnitude-invariant stress drops with dynamic weakening*

Hannah Rabinowitz, Columbia University in the City of New York, *Detecting seismic signatures in the rock record at the Japan Trench*

Raymundo Omar Plata Martinez, National Autonomous University of Mexico, *Radiated seismic energy of aftershocks of the 20 March 2012 earthquake, Mw7.5, Ometepec-Pinotepa Nacional, Mexico*

Space Physics and Aeronomy

Coordinators: Brian Welsch, Allan Weatherwax, Elizabeth Mitchell

Landon B. Terry, Utah State University, *Implementation of a high-altitude balloon payload to study thermospheric wind speeds through redline airglow emissions of atomic oxygen at 630 nm via a split-field etalon Doppler imager utilizing a Fabry-Perot interferometer*

Neil Hindley, University of Bath, *On the southern gravity wave hot spot: An individual waves study with cosmic GPS-RO*

Karthik Venkataramani, Virginia Polytechnic Institute and State University, *Contributions of the higher vibrational levels of nitric oxide to the radiative cooling of the thermosphere*

Phyllis Whittlesey, University of Alabama in Huntsville, *Testing the Solar Probe Cup, an instrument designed to touch the Sun*

Patrick Tracy, University of Michigan, *Heavy ion temperatures as observed by ACE/Swics*

Chao Yue, University of California, Los Angeles, *Determining substorm onset location using 3D empirical force-balanced pressure and magnetic field models for substorm growth phase*

Lois Smith, University of Michigan, *The disappearance of the post-midnight high energy ion plasmasphere*

Bea Gallardo-Lacourt, University of California, Los Angeles, *Influence of auroral streamers on rapid evolution of SAPS flows*

Ashley Carlton, Massachusetts Institute of Technology, *Using geostationary communications satellites as a sensor: Telemetry search algorithms*

Oliver Hartkorn, University of Cologne, *A model of Callisto's ionosphere*

Study of Earth's Deep Interior

Coordinators: Allen McNamara, Sabine Stanley, Guole Shi

Miles Bodmer, University of Oregon, *Shear wave splitting observations across the Juan de Fuca plate system: Ridge-to-trench constraints on mantle flow from 2 years of Cascadia Initiative OBS data*

Joseph Byrnes, University of Oregon, *Structure of the lithosphere-asthenosphere system beneath the Juan de Fuca plate: Results of body wave imaging using Cascadia Initiative data*

Tectonophysics

Coordinators: Philip Ball, Andrea Tommasi

Juan Carlos Rosas, University of Alberta, *Thermal models of the Costa Rica–Nicaragua subduction zone: The effect of a three-dimensional oceanic plate structure and hydrothermal circulation in the temperature distribution and mantle wedge dynamics*

Rachael Bullock, University of Durham, *Earthquake rupture in shallow, unconsolidated sediment*

Andrew J. Parsons, University of Leeds, *Microstructural analysis of the Greater Himalayan Sequence, Annapurna-Dhaulagiri Himalaya, central Nepal: Channel flow and orogen-parallel deformation*

Tianze Liu, Stanford University, *The lithospheric structure of Ordos, China: Evidence from refined virtual deep seismic sounding (VDSS)*

Jean-Arthur Olive, Massachusetts Institute of Technology, *Modes of extensional faulting controlled by surface processes*

Ekbal Hussain, University of Leeds, *The relationship between coseismic slip and postseismic creep*

Austin Elliott, University of California, Davis, *Slip rate gradients along parallel strands of the eastern Altyn Tagh fault confirm modeled rupture behavior at a transpressional bend*

Tianhaozhe Sun, University of Victoria, *Studying near-trench characteristics of the 2011 Tohoku-Oki megathrust rupture using differential multi-beam bathymetry before and after the earthquake*

Zachary Eilon, Columbia University in the City of New York, *A joint inversion for velocity and anisotropy structure beneath a highly extended continental rift*

Volcanology, Geochemistry, and Petrology

Coordinators: Tyrone Rooney, Sean Mulcahy, Noah McClean, Brian Dreyer, Michelle Coombs, Fang-Zhen Teng, Sarah Brownlee, Michael Bizimis, Sarah Lambart, Eric Brown, Qi Fu

James Cowlyn, University of Canterbury, *Insights into proximal-medial pyroclastic density current deposits at a high-risk glaciated volcano: Mt Ruapehu, New Zealand*

Matylda Hermanska, University of Iceland, *Geochemistry of multicomponent fluid phases in the Krafla high-enthalpy geothermal system, NE Iceland*

Tyler Brown, University of Wyoming, *Towards solving the conundrum of fast-spread ocean crust formation: Insights from textural analysis of gabbroic rocks from Pito Deep and Hess Deep, East Pacific Rise*

Jenni L. Hopkins, Victoria University of Wellington, *Trace element geochemistry of basaltic tephra in maar cores: Implications for centre correlation, field evolution, and mantle source characteristics of the Auckland Volcanic Field, New Zealand*

Tom D. Pering, University of Sheffield, *Observations on multi-slug activity—Implications for volcanic processes*

Jacqueline T. Salzer, University of Potsdam, *Spatial and temporal patterns of dome extrusion during the 2004-2008 eruption of Mount St. Helens*

Mark Stelten, University of California, Davis, *The dynamics of the post-caldera magmatic system at Yellowstone: Insights from age, trace element, and isotopic data of zircon and sanidine*

Kellie Wall, Washington State University, *Oxygen fugacity recorded by xenoliths from Pacific oceanic islands*

Joshua S. Mendez Harper, Georgia Institute of Technology, *The microphysics of ash tribocharging: New insights from laboratory experiments*

RESEARCH SPOTLIGHT

Changing Patterns in U.S. Air Quality

Smokestacks in New Jersey emit pollutants, which affect the chemistry of the air.

Monthly mean ground-level ozone peaks during the summer over polluted midlatitude regions, with ozone production fueled by regionally emitted nitrogen oxides (NO_x), abundant biogenic volatile organic compounds (VOCs), and sunlight. Using a global chemistry-climate model to simulate ozone during the 21st century, *Clifton et al.* show that the seasonality of ground-level ozone could reverse over the northeastern United States before midcentury. They attribute this shift to large reductions in eastern U.S. NO_x emissions. Observations indicate this shift is already happening because the summertime peak has broadened in recent years.

Nitrogen oxides are produced as a by-product of combustion—high temperatures cause nitrogen and oxygen in the atmosphere to react. Photochemical reactions involving NO_x and VOCs, including methane, contribute to the formation of ground-level ozone. Although ozone plays an important role in the upper atmosphere as a shield against ultraviolet radiation, at ground level it is a hazardous pollutant.

The authors find that doubling global methane—a strong, well-mixed greenhouse gas and precursor to baseline levels of ozone—increases monthly mean ground-level ozone during all months, especially wintertime and early spring, when the ozone lifetime is longest. Thus, although NO_x reductions change the shape of the northeastern U.S. ground-level ozone seasonal cycle, rising methane amplifies the winter-spring peak.

In the absence of changes in ozone precursor emissions, global climate warming is expected to increase peak summertime ground-level ozone. Additional regional NO_x emission reductions can mitigate this adverse effect of climate warming on summertime ozone pollution. (*Geophysical Research Letters,* doi:10.1002/2014GL061378, 2014) **—Colin Schultz, Freelance Writer**

How a River Gets Its Width

A view of the Vermillion River near Hastings, Minn.

Minnesota's Vermillion River meanders some 112.7 kilometers before hitting the Mississippi River, passing through myriad tree-lined banks and rocky beaches along the way. What gave this river its width? A team of researchers thinks they now know.

Eke et al. have published a new model that allows scientists to look at the role of interacting bank processes such as deposition and erosion in setting a river's width. Past models have required scientists to artificially set the river at a constant width instead of letting it emerge naturally with realistic variations based on input conditions.

The team used the Vermillion River as their test case and found surprising complexity in the evolutionary path a river takes before reaching a stable width. Even the slightest changes in bank conditions can alter its course. The researchers also found that a diverse array of bank conditions can create rivers with identical widths.

A river's width changes as banks erode and take on fresh deposits because of encroaching vegetation and crumbling beaches. The model allows such banks to move independently. After applying the numerical technique across a wide range of rivers, the researchers found their results were in agreement with what they saw in nature.

The team hopes this link between a meandering river and its banks will give other scientists a fresh perspective to look at long-studied rivers. (*Journal of Geophysical Research: Earth Surface*, doi:10.1002/2013JF003020, 2014) **—Eric Betz, Freelance Writer**

Found: The Submarine Source of an 1891 Eruption Near Sicily

After an underwater eruption in 1891, lava balloons floated to the coasts of Italy's Pantelleria Island, seen here.

In 1891, an underwater volcano of the Pantelleria volcanic complex, located offshore of Italy's Pantelleria Island, in the Strait of Sicily, erupted. This is the only recorded volcanic eruption of this complex in history, and, until now, no one knew which volcano had erupted.

More than 120 years after the fact, *Conte et al.* integrated different data from multiple sources to ultimately identify the location as well as the style of the eruption. Their results help improve scientists' knowledge of underwater volcanic eruptions in shallow waters as well as the rare types of eruptions that produce lava balloons, the researchers explain.

Lava balloons are hollow chunks of lava that encase a gas-filled cavity. These chunks float to the surface, but they have only been observed in a handful of submarine eruptions, including the offshore eruptions near Pantelleria, Italy, in 1891; Mauna Loa, Hawaii, in 1877; Socorro Island, Mexico, in 1993; and El Hierro, Canary Islands, in 2011.

Using high-resolution bathymetry, the researchers studied the seafloor pertaining to the Pantelleria volcanic complex, as well as the texture, the chemistry, and the age of samples collected near the vent location of the 1891 eruption.

The team compared their chemical data to those reported by historical analyses of volcanic balloons taken in 1891, and they found a significant match between the samples. Bathymetric data used to map the seafloor, along with volcanic products features, were combined to constrain the site of lava balloon emissions. Moreover, the team explained the formation of lava balloons, bombs, and glass ash-sized grains emitted during the 1891 explosive activity.

The results point to a small submarine volcanic vent located about 300 meters southwest of the location originally reported in 1891. The cone is 90 meters high and at least 250 meters deep and has a volume of 700,000 cubic meters. The vent sits within a newly discovered submarine volcanic field northwest of Pantelleria Island. (*Geochemistry, Geophysics, Geosystems*, doi:10.1002/2014GC005238, 2014) **—Jessica Orwig, Freelance Writer**

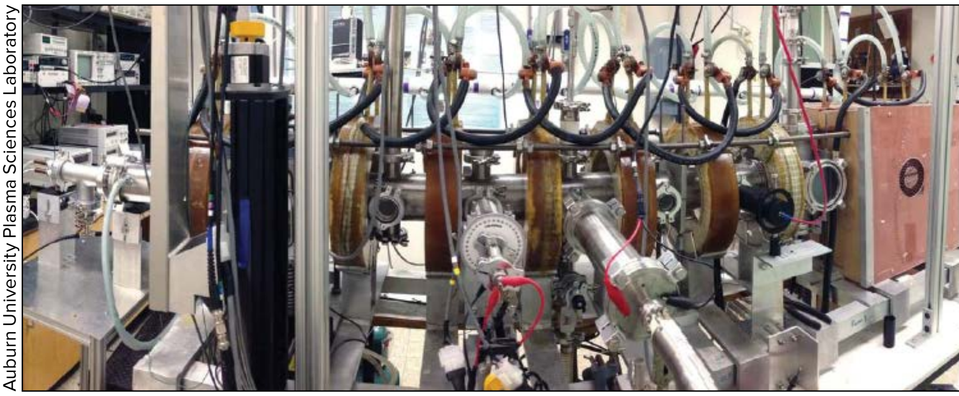
What Causes Broadband Electrostatic Noise in Space?

Since the 1970s, scientists have observed broadband electrostatic noise (BEN) coming from boundary layer regions in the Earth's magnetosphere. Until recently, the cause of that noise was not well understood.

Last year, Ami DuBois and a team of researchers were the first to experimentally show that by compressing a magnetized plasma—such as the plasma that makes up the magnetospheric boundary layer—she could create BEN. This year, *DuBois et al.* took the research one step further and examined more closely how compression produces BEN.

Using the Auburn Linear Experiment for Instability Studies (ALEXIS) device, the researchers produced a magnetized plasma that was subjected to a spatially localized electric field. In space, solar wind compression gives rise to similar electric fields within the magnetospheric boundary layer that intensify during active periods. By varying the magnetic field strength, the researchers simulated different magnitudes of compression and observed a continuous transition between different shear-driven behaviors to identify exactly which factors lead to BEN.

Knowing why BEN occurs can improve the community's understanding of the magnetospheric boundary layer and other plasma boundary layers in space that affect near-Earth space weather. (*Journal of Geophysical Research: Space Physics*, doi:10.1002/2014JA020198, 2014) **—Jessica Orwig, Freelance Writer**



Auburn University Plasma Sciences Laboratory

The Auburn Linear Experiment for Instability Studies (ALEXIS) helps scientists understand the factors that produce broadband electrostatic noise in boundary layers of the Earth's magnetosphere.

Reduced Emissions Lead to Clearer Skies over Alabama

In rural Alabama, as in the rest of the country, human-made aerosols reduce visibility. Particles are in the atmosphere year round, but in the humid summer season, the concentration of pollutants—and their effects—peaks. In addition to making the air murky, aerosols are bad for human health. A new study investigates the historical trend of these effects.

Across the nation, emissions of an important aerosol precursor are on the decline: From 1990 to 2010, the country saw a 60% reduction in sulfur dioxide emissions, thanks to the 1990 Clean Air Act Amendments. In Alabama, the past decade brought reductions of nearly 10% per year. Volatile organic compounds (known as VOCs) are the other major contributor to aerosol in the southeastern United States. These predominantly come from biogenic sources and have decreased much more slowly. Overall, total aerosol mass is decreasing, and its relative composition is changing.

With this in mind, *Attwood et al.* measured aerosol optical extinction as a function of humidity using a spectrometer in an Alabaman forest. Researchers used the site and its climate to represent the southeastern United States. Combining their findings with historical data, they created a picture of how particles that contain less sulfate, an ion that originates from sulfur dioxide, absorb less water. Visibility is improving in the southeastern United States because there is less aerosol mass and because the aerosol is becoming less water absorbing.

The calculated improvement in visibility due to decreasing aerosol mass was 3.4% per year during 2001–2013, with changing water absorption accounting for an additional 1.1% per year improvement. This dramatic change has been confirmed using satellite records of aerosol optical depth and visibility records at airports. (*Geophysical Research Letters*, doi:10.1002/2014GL061669, 2014) **—Shannon Palus, Freelance Writer**

Robert Wild, NOAA/University of Colorado

View of a field site in central Alabama where researchers measured aerosol properties as a function of humidity during summer 2013.

Ham Radio as an Operational and Scientific Instrument

Solar flares can send powerful radiation and energetic particles toward Earth, disrupting communications. Typically, these events are monitored and forecast with satellite observations and networks of specially designed instruments, but detailed studies could also get a boost from amateur radio operators on Earth, report *Frissell et al.*

Amateur radio, popularly known as ham radio, uses frequency bands in the radio spectrum that are set aside for noncommercial use. Particularly in the 1.8- to 30-megahertz bands, the geographic range of ham communication depends on the conditions of the ionosphere—the layer of the atmosphere roughly 85 to 600 kilometers high, which is ionized by the Sun's radiation. The layers within the ionosphere can reflect signals back to Earth, allowing operators to communicate, often with Morse code, across continents and oceans. These communications may be disrupted by significant space weather events, such as blasts of radiation from solar flares suddenly impacting Earth's upper atmosphere.

In recent years, ham operators have established global networks of radio stations to monitor ionospheric conditions in real time, sometimes using automated equipment and software that allows for continuous monitoring across multiple bands. This makes these networks potentially helpful to scientists who study space weather.

To demonstrate, the authors compare data from one such network, the Reverse Beacon Network (RBN), with observations from the U.S. National Oceanic and Atmospheric Administration's Geostationary Operational Environmental Satellite-15 (GOES-15) during a powerful solar flare on 13 May 2013. Just before GOES-15 observed the flare's peak, RBN had thousands of links between stations in its network, including more than 1100 links operating on high-frequency bands from 7 to 28 megahertz across Europe, North America, South America, and Africa.

Immediately after the peak, more than 65% of all radio links on RBN dropped out, and nearly all communication on the 7- and 28-megahertz bands was lost. South America and Africa were completely cut off, and most links between the United States and Europe fell silent. Thirty minutes after the flare's peak, conditions began to improve, and some transatlantic communication was restored, as well as some links to the Southern Hemisphere.

This event demonstrates both the global spatial coverage and diverse frequency space observed by just one amateur radio network. Amateur radio data sets have great potential for validating space weather models and helping scientists understand how the ionosphere behaves on a variety of spatial and temporal scales. The real-time nature of these networks also makes them useful for space weather nowcasting.

Ann Marie Rogalcheck-Frissell

Joseph Przebieglec (left; ham radio call sign KC2NSS) and Nathaniel Frissell (right; call sign W2NAF) install a simple G5RV-type wire antenna on the roof of a house. Simple antennas such as these allow amateur radio operators around the world to transmit on high frequencies and contribute to data collected by the Reverse Beacon Network and other real-time amateur radio reporting networks.

Because ham radio equipment is, by nature, not standardized and is run by enthusiasts who operate in their free time and can afford to purchase it, there are geographical biases in the data. However, by incorporating the ham networks with other data sources—and perhaps encouraging greater standardization by participating ham radio operators in the future—the authors think the data will prove a valuable addition to space weather science. (*Space Weather,* doi:10.1002/2014SW001132, 2014) **—Mark Zastrow, Freelance Writer**

Fluctuations in Atlantic Meridional Overturning Circulation

The Atlantic Meridional Overturning Circulation (AMOC) is a large-scale convection cell in the Atlantic Ocean that transports warm surface water from the tropics northward and colder deeper water from the North Atlantic southward. Now a study suggests that observed interannual fluctuations in the AMOC may be forced by changes in wind patterns. Understanding the mechanisms contributing to the AMOC fluctuations is important for future climate studies.

Nearly 90% of the heat transported by the ocean at 26°N latitude is carried by AMOC. However, AMOC can fluctuate—it increased in flow from 2004 to 2005 and subsequently decreased, reaching a minimum in the 2009–2010 winter. Heat transport fluctuations impact weather patterns on both regional and larger scales. Earlier studies showed that AMOC variations are directly linked to the summer climates of North America and western Europe.

Zhao and Johns sought to explain the physical mechanisms for the observed AMOC variability. Typically, scientists rely on theoretical analysis and numerical models to explain AMOC variations because of a lack of observational data. The authors combined daily measurements of AMOC at 26.5°N from 2004 to 2011 and numerical models to explain the observed variability.

Three separate components make up the upper branch of the AMOC at 26.5°N latitude: the Gulf Stream, Ekman transport, and upper mid-ocean (UMO) transport. The team compared the fluctuations of AMOC with the fluctuations of each component. The numerical models show that AMOC variations are driven by wind. Although the Gulf Stream and Ekman transport play important roles, UMO was found to be the dominant component in AMOC fluctuations. (*Journal of Geophysical Research: Oceans*, doi:10.1002/2013JC009407, 2014) **—Catherine Minnehan, Freelance Writer**

Survival of Young Sardines Flushed Out to Open Ocean

Schools of Pacific sardines spawn in the cool waters off the California coast. Previous studies suggest that the fish would thrive in large-scale eddies that are common in the California current system, but the effects of eddies and streamers on sardine survival remain unclear. Do sardines survive there because eddies contain suitable habitat or because an inherent property of eddies confers some kind of advantage—and does this advantage translate into healthy adult populations?

Nieto et al. now demonstrate that eddies and streamers simply entrain coastal waters that form ideal sardine habitat, carrying the developing larvae offshore. To determine this, the researchers combined ship-based observations of sardine eggs with satellite measurements of sea surface temperatures, chlorophyll concentrations, and ocean circulation. They also used a statistical model to evaluate the importance of different environmental factors.

The researchers expected that expanded spawning habitat would benefit sardine populations, especially because the small fish can theoretically survive in the open ocean. However, their results showed just the opposite. When the scientists compared the offshore extent of spawning habitat to an index of sardine recruitment success, they found that larval sardines fared worse the farther from shore they were transported.

The researchers hypothesized that this may occur because it becomes increasingly difficult for young sardines to migrate back to coastal waters. Their results refocused the view that eddies are beneficial to survival to a new perspective that eddies and streamers are a sink for sardine offspring where offshore transport leads to poor survival. (*Journal of Geophysical Research: Oceans*, doi:10.1002/2014JC010251, 2014) **—Julia Rosen, Freelance Writer**


Adam Fagen, CC BY-NC-SA 2.0

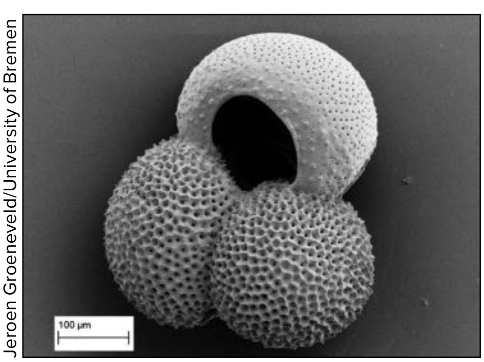
A school of Pacific sardines, swimming off the coast of Monterey, Calif.

Sea Surface Temperature Change During the Pleistocene

The last glacial period on Earth marks the end of the Pleistocene about 11,700 years ago. The warming temperatures in the Pleistocene are primarily attributed to increasing concentrations of atmospheric carbon dioxide that drove up tropical sea surface temperatures (SSTs) in the Pacific Ocean. However, new evidence indicates that a different mechanism may have helped temperatures to rise.

Dyez and Ravelo report the first measurements of SST changes over time within the western Pacific warm pool. Their results suggest that changes in the temperature of upwelled source water, in addition to atmospheric carbon dioxide concentrations, played a significant role in warming Pacific SST toward the end of the Pleistocene.

To assess past SSTs of both equatorial and off-equatorial regions of the western Pacific warm pool, the researchers analyzed microscopic shells found in the sediment record of the ocean floor. These shells are from planktonic forams, tiny creatures that lived in surface waters; their shells filtered down to the seabed upon their deaths. The ratio of magnesium to calcium within forams of different sediment layers gives an indication of SSTs when the foraminifera lived.



Jeroen Groeneveld/University of Bremen

Scientists looked at the chemical makeup up planktonic foraminifera (specifically from Globigerinoides ruber, seen here in an image taken with a scanning electron microscope) to investigate how temperatures changed in the past

The researchers looked at forams from two different Ocean Drilling Program cores. The first site is located along the equatorial line within the western Pacific warm pool; the second is at a latitude outside the pool, around 5°N. Both cores span a time period of 0.04 to 1.41 million years ago.

If greenhouse gas concentrations were the only thing affecting SSTs at the time, SSTs calculated for both sites would be roughly the same. However, comparing the SST records from the sites revealed that SSTs in the western Pacific warm pool were higher than those calculated for the other site.

The authors show that heat from upwelled water in the warm pool affected its surface temperature in a significant and recordable way. Heat from this upwelling, in turn, may have influenced surrounding climate and helped to transform conditions from across the mid-Pleistocene transition, about 900,000 years ago, the authors posit. (*Geophysical Research Letters*, doi:10.1002/2014GL061639, 2014) **—Jessica Orwig, Freelance Writer**

Atmospheric Sciences

Program Director – National Suborbital Education and Research Center University of North Dakota

The University of North Dakota seeks a Program Director to manage the National Suborbital Education and Research Center (NSERC). NSERC provides science mission operations support to meet the research, education, and technology needs of the NASA Airborne Science Program and the scientific community. The Program Director will be responsible for science operations support for various aircraft platforms, including the DC-8, P-3B, C-130, Global Hawks, and ER-2s, as well as for interfacing to the scientific community. Duties include mission planning, personnel scheduling, budgeting, logistical support, and supervision of NSERC staff. In addition, the Program Director will be expected to lead the implementation of improvements that will make the various airborne platforms more scientifically valuable. The Program Director will also be responsible for the organization and improvement of training and communications for the Airborne Science Program including the annual NASA Student Airborne Research Program (SARP).

Qualifications include a graduate degree in a natural or physical science, or in engineering. Extensive experience directing research from multiple aircraft platforms is also required. Significant management experience is required including financial and personnel management. The Program Director will be expected to have strong interpersonal and leadership skills, as well as an ability to communicate effectively with a broad spectrum of clientele including NASA Headquarters management. He or she should also demonstrate an ability to collaborate with scientists and aircraft operations personnel. Experience directing student research is highly desirable. A history of success earning external funding will be a plus.

Applicants are required to be eligible for employment under U.S. export control laws and must meet the requirement of being a “U.S. Person” (U.S. citizen, a lawful permanent resident, refugee, or granted asylum) or must be eligible to obtain appropriate U.S. Government authorization for access to export controlled equipment, technology, or software. UND will not sponsor an applicant for employment authorization for this position. All information collected in this regard will only be used to ensure compliance with U.S. export control laws, and will be used in compliance with all laws prohibiting discrimination on the basis of national origin and other factors.

NSERC is affiliated with the Earth System Science and Policy Department within the John D. Odegard School of Aerospace Sciences at the University of North Dakota. More information is at http://www.nserc.und.edu/. NSERC is funded through a long-term cooperative agreement with NASA. This opening is a twelve-month, non-tenure-track faculty position with the possibility of renewal.

Interested candidates should submit a CV, list of publications, statement of research and education interests, and contact information for three references to: Karen Katrinak, NSERC, UND Earth System Science & Policy Dept., Clifford Hall Rm 300, 4149 University Avenue Stop 9011, Grand Forks, ND 58202-9011; phone (701) 777-2482; fax (701) 777-2940. Applications may be e-mailed to: k.katrinak@nserc.und.edu. This is Position #23851.

Applicants are invited to provide information regarding their gender, race and/or ethnicity, veteran's status and disability status on the form found at http://und.edu/affirmative-action/apcontrolcard.cfm. This information will remain confidential and separate from your application.

The University of North Dakota is an Affirmative Action/Equal Opportunity Employer. The University of North Dakota encourages applications from women, minorities, veterans, and individuals with disabilities.

The University of North Dakota determines employment eligibility through the E-Verify System.

North Dakota veterans' preference does not apply to this position.

The University of North Dakota complies with the Jeanne Clery Disclosure of Campus Security Policy & Campus Crime Statistics Act. Information about UND campus security and crime statistics can be found at http://und.edu/discover/_files/docs/annual-security-report.pdf.

Ocean Sciences

Horizon Marine Seeks MetOcean Analyst

Description

Horizon Marine, Inc., a leader in commercial oceanography, provides data-driven metocean forecasting for the global offshore energy industry to improve situational awareness, reduce downtime, protect the environment, and enhance safety. Due to continued growth and increasing demand for its services, the company is seeking a Metocean Analyst to join our expanding team in Marion, Massachusetts.

Job Description

Primary responsibilities as MetOcean Analyst include research, compilation, and analysis of oceanographic data to provide daily written reports on real-time ocean current monitoring and forecasting for the offshore energy industry (occasional weekend duty is required). Other tasks include data analysis and summary reports for site-specific metocean studies; presentation of relevant results in professional science, industry meetings, and publications; and pursuing additional projects as time allows and according to capability. Desired: BS in physical or marine science; excellent oral and written communications skills; a creative approach to widely varied problems; and a high level of computer literacy including scientific programming experience (e.g. Matlab) in Windows and Unix environments. Opportunities for continued education and travel.

Please send a cover letter and resume addressing the above requirements and listing special skills to:

Patrice Coholan, President
Horizon Marine, Inc.
15 Creek Road
Marion, MA 02738
hr@horizonmarine.com
www.horizonmarine.com

Vacancy Announcement Tenure Track Assistant Professor in Chemical Oceanography

December 2014

The School of Fisheries and Ocean Sciences (SFOS) at the University of Alaska Fairbanks (UAF) seeks applications from exceptional candidates for a tenure-track assistant professor position in chemical oceanography. Specialties of interest include ocean acidification, marine inorganic carbon chemistry, carbon biogeochemistry, carbon cycle-climate interactions, isotope biogeochemistry, and evaluation of the biological impact of ocean acidification. We are particularly interested in applicants whose research plan involves the new ice-capable, Global Class Research Vessel Sikuliaq.

UAF is Alaska's research university, North America's Arctic university and a world leader in Arctic and climate change research. The successful applicant will enjoy opportunities for collaboration within SFOS's vibrant high-latitude research program. The School offers a Minor in marine science, and MS and PhDs in oceanography and in marine biology. The UAF campus houses the Ocean Acidification Research Center (OARC), Alaska Stable Isotope Facility (ASIF), UAF's Advanced Instrumentation Laboratory (AIL), the Core Facility for Nucleic Acid Analysis, and is linked to the joint NOAA, UAF Kasitsna Bay Laboratory, Alaska SeaLife Center and the Seward Marine Center. SFOS has over 60 faculty based throughout Alaska and over 150 graduate students engaged in thesis research in Alaska waters, and throughout the world.

Applicants must hold a Ph.D. in oceanography or closely related discipline, and preferably have post-doctoral and teaching experience. The position requires research, education and service that support Alaska's ocean resources and the communities that rely on them. The successful candidate will be expected to teach core and/or develop specialty oceanography courses for the graduate and undergraduate academic programs, develop a vigorous externally-funded research program and mentor graduate students. Applicants must submit a statement of interest that outlines their qualifications for this position and includes a research plan, teaching statement, curriculum vitae, and names and contact information of at least three references. Applications must be submitted to Job Posting #0069942 at https:// www.uakjobs.com. For questions about the position, please contact Dr. Matthew Wooller, chair of the search committee, at mjwooller@alaska.edu. Review of applications will begin February 15th. For full consideration applications should be received by March 1st, 2015.

Solid Earth Geophysics

VISITING ASSISTANT PROFESSOR

Bucknell University's Department of Geology and Environmental Geosciences in Lewisburg, PA, seeks to hire a visiting assistant professor to teach two introductory lecture sections of physical & environmental geology with two accompanying lab sections in the 2015 Fall semester. For full details and/or to apply on line, please visit http://apply.interfolio.com/28829. Review of applications will begin April 6, 2015. A position description can also be viewed on the Bucknell Department of Geology and Environmental Geosciences website at http://www.bucknell.edu/Geology. Bucknell University, an EEO Employer, believes that students learn best in a diverse, inclusive community and is

therefore committed to academic excellence through diversity in its faculty, staff, and students. We seek candidates who are committed to Bucknell's efforts to create a climate that fosters the growth and development of a diverse student body, and we welcome applications from members of groups that have been historically underrepresented in higher education.

Interdisciplinary/Other

Assistant or Associate Professor with focus on Radiative Transfer and/or Remote Sensing. The College of Earth, Ocean, and Atmospheric Sciences at Oregon State University located in Corvallis, Oregon invites applications full-time (1.0 FTE) 12 month tenure-track position. We seek a colleague to develop and maintain a vigorous, externally funded research program in remote sensing and/or modeling of processes directly linked to the Earth's radiative energy budget. This position is motivated by the core importance of radiative transfer in the study of atmospheric processes and climate. Areas of research may include: (1) Remote sensing of the atmosphere and surface fluxes; (2) Examining the radiative effects of aerosols and clouds on climate; (3) Designing and implementing remote sensing algorithms and methods; and (4) Developing parameterizations for clouds and radiative transfer in atmospheric models. This position will participate in undergraduate and graduate teaching program and contribute to teaching courses in radiative transfer, remote sensing techniques, climate dynamics, and atmospheric physics, and advise/mentor students and/or postdocs. Requires: Ph.D. in atmospheric science, oceanography, or a closely related field by the start of employment; scholarly potential demonstrated by a record of peer-reviewed publications and a clearly defined research agenda; potential for establishing a funded research program; potential for teaching excellence, student success, mentoring students and postdocs. For CEOAS information see: http://ceoas.oregonstate.edu To apply go to: http//oregonstate.edu/jobs posting number 0013916. For full consideration, apply by 04/06/2015. Closing date: 06/01/2015.

Colorado School of Mines Department of Geophysics Associate or Full Professor - Reservoir Characterization

Colorado School of Mines Department of Geophysics invites applications for a regular academic faculty position in Geophysics, which is anticipated to be filled at the rank of Associate or Full Professor. For this position we seek an individual with a distinguished international reputation in seismic techniques applied to exploration for, and development of, natural resources, who can integrate geophysical methods with applicable multi-disciplinary data for successful reservoir characterization.

Candidates must possess a doctoral degree in geophysics or a related field. Candidates must also possess superb interpersonal and communication skills and a collaborative style of research and teaching, and must have experience in collaboration with industry. Preference will be given to candidates whose research interests hold potential for multidisciplinary collaboration.

For the complete job announcement and directions on how to apply, visit: http://inside.mines.edu/HR-Academic-Faculty

Mines is an EEO/AA employer.

Director, Advanced Energy Technology Initiative Illinois State Geological Survey

Prairie Research Institute

University of Illinois at Urbana-Champaign

The Illinois State Geological Survey (ISGS) is part of the Prairie Research Institute (PRI) at the University of Illinois at Urbana-Champaign which is centrally located between Chicago, St. Louis, and Indianapolis. PRI houses five large scientific surveys covering a wide range of expertise including biology, water resources, climate, geology, sustainable technology and archaeology. The ISGS is a premier state geological survey, with over 200 scientists and technical support staff, serving the needs of the public, government, and industry with earth science information and research relevant to natural resources, environmental quality, economic vitality, and public safety. The University is a land-grant institution that provides access to world-class laboratory and academic facilities, Big Ten athletic events, and internationally acclaimed cultural opportunities.

We are seeking an individual to provide leadership, clear scientific vision, and direction to the subdisciplines and staff members that comprise the Advanced Energy Technology Initiative (AETI) at the ISGS. The leadership skills of the individual will encourage multidisciplinary, project-based research within AETI and throughout ISGS, other Surveys, and University related to energy issues; develop, implement, and administer research and service programs of the AETI; and facilitate coordination, communication, and teamwork throughout the PRI and the University. As the Director of AETI, the individual will promote AETI services and capabilities to a variety of stakeholders including government funding agencies, corporations, and legislative representatives. The individual will continue to maintain AETI's domestic and international reputation as a global leader in addressing energy issues.

Ph.D. in geological science, engineering, or related discipline with career emphasis related to energy resources and 15 years of combined research and managerial experience beyond the completion of master's degree. Demonstrated vision, capability, and experience to address challenges facing society related to the advanced energy fields, such as carbon capture and storage, mitigation of fossil fuel emissions, water for energy resource development and power generation, public engagement and education on energy issues, unconventional oil and natural gas resource assessment, natural gas geologic storage, and enhanced oil recovery.

Applications must be received by May 15, 2015. Applicants may be interviewed before the closing date; however, no hiring decision will be made until after that date. To apply, please visit https://jobs.illinois.edu/academic-job-board to complete an online profile and to upload a 1) cover letter, 2) rÈsumÈ/CV, 3) the names and contact information (including e-mail addresses) of three professional references. All requested information/documentation must be submitted for your application to be considered. An incomplete application will not be reviewed.

For further information please contact Lori Walston-Vonderharr, Human Resources, Illinois State Geological Survey, at lwalston@illinois.edu or 217-244-2401.

The University of Illinois is an EEO Employer/Vet/Disabled http://inclusiveillinois.illinois.edu/

GDL Foundation Fellowships in Structure and Diagenesis

The GDL Foundation supports study and research of chemical and mechanical interactions, structural diagenesis, in sedimentary basins. Practical applications are of particular interest.

We are currently seeking applications from M.S. and Ph.D. candidates, post-doctoral researchers, and scientists for fellowships, up to $10,000, based on specific proposals for research and participation in meetings and conferences to share results.

Submit applications (available at: www.gdlfoundation.org) by April 1, 2015.

Lab manager in Organic/Isotope Geochemistry at CU Boulder

The Organic and Isotope Geochemistry Group in the Department of Geological Sciences and INSTAAR at the University of Colorado Boulder is seeking a highly qualified laboratory manager to oversee its new, state-of-the-art analytical facility starting in Fall 2015. Applications are accepted electronically at www.jobsatcu.com/postings/94809 (posting number RF02151). Review of applications will begin on late March and will be accepted until the position is filled. Interested candidates should contact Dr. Julio Sep˙lveda directly with any inquiries about this position (jsepulved@colorado.edu

POST-DOCTORAL TEACHING ASSOCIATE IN MINERALOGY

UNIVERSITY OF TENNESSEE

The Department of Earth and Planetary Sciences (http://web.eps.utk.edu) at the University of Tennessee in Knoxville invites applications for a Post-doctoral Teaching Associate position in Mineralogy starting August 1, 2015, pending approval of funding. The position is a 9-month appointment and includes benefits. Successful candidates will be expected to teach mineralogy for undergraduate geology majors, physical geology at the entry level, and possibly a specialized mineralogy or petrology course at the upper division undergraduate or

POSTDOCTORAL, RESEARCH AND VISITING RESEARCH SCIENTISTS ATMOSPHERIC AND OCEANIC SCIENCES PRINCETON UNIVERSITY/GFDL

In collaboration with NOAA's Geophysical Fluid Dynamics Laboratory (GFDL), the Atmospheric and Oceanic Sciences Program at Princeton University solicits applications to its Postdoctoral, Research, and Visiting Research Scientist Program.

The AOS Program and GFDL offer a stimulating environment with significant computational and intellectual resources in which to conduct collaborative or independent research. We primarily seek applications from recent Ph.D.s for postdoctoral positions but will accept applications from more experienced researchers. Applications from independent researchers and more senior scientists who may need partial support for sabbatical or short visits may also be considered. Postdoctoral appointments are initially for one year with the possibility of renewal for a second year based on satisfactory performance and continued funding. A competitive salary is offered commensurate with experience and qualifications.

We seek applications in all areas of the climate sciences. This includes research in basic processes in atmospheric and oceanic dynamics; climate dynamics, variability and prediction; atmospheric physics and chemistry; cloud dynamics and convection; boundary layer processes; land-sea-ice dynamics; continental hydrology and land processes; physical oceanography; ocean-atmosphere interaction; climate diagnostics and analysis. Applicants must have a Ph.D. in a relevant discipline by the time their appointment starts.

Further information about the Program may be obtained from: http://www.princeton.edu/aos/.

Applicants are encouraged to contact GFDL and Princeton University scientists prior to application.

Complete applications, including a CV, copies of recent publications, names and contact information for at least 3 references in order to solicit letters of recommendation, and a titled (about three page) research proposal should be submitted by April 1, 2015 for full consideration. Applicants should apply online to http://jobs.princeton.edu, Requisition #1500110. These positions are subject to the University's background check policy. Princeton University is an equal opportunity employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, national origin, disability status, protected veteran status, or any other characteristic protected by law.

graduate level. Candidates will also be encouraged to participate in departmental research projects and/or work on their own research.

UT-Knoxville is the state's flagship research institution, located in East Tennessee close to Oak Ridge National Laboratory and the Great Smoky Mountains National Park. The Department of Earth and Planetary Sciences comprises an energetic group of tenure-track and research faculty, post-doctoral researchers, and ~150 graduate and undergraduate students.

Applicants should e-mail rÈsumÈ, description of teaching and research interests, and contact information for 3 references in PDF format to Prof. Josh Emery, search committee chair, University of Tennessee, Knoxville, TN 37996-1410; Phone: 865-974-8039; E-mail: <jemery2@utk.edu>. The applicant should also arrange to have 3 letters of reference e-mailed to the same address. Review of applications will begin April 1, 2015 and will continue until the position is filled.

The University of Tennessee is an EEO/AA/Title VI/Title IX/Section 504/ADA/ADEA institution in the provision of its education and employment programs and services. All qualified applicants will receive equal consideration for employment without regard to race, color, national origin, religion, sex, pregnancy, marital status, sexual orientation, gender identity, age, physical or mental disability, or covered veteran status.

The stable isotope lab at Duke (DEVIL) seeks new clients for 13C,15N, 2H and 18O analyses. Quick turn-around for EA, GC-C, TCEA, dual inlet, GasBench. 20% discount for first-time clients. Contact Jon Karr at jkarr@duke.edu or 919-660-7418.http://nicholas.duke.edu/devil/

Two Job Openings: Computational Earth Science Group, Los Alamos National Laboratory

Deputy Group Leader, Computational Earth Science Group, Job ID# IRC37040 This position is 50% management and 50% technical/science in either atmospheric modeling or subsurface flow and transport modeling. Scientist 3/4: Subsurface Flow and Transport Modeling, Job ID# IRC36086 This position is for an experienced professional (generally greater than 5 years since degree) in the general area of computational hydrology, reservoir simulation, computational fluid dynamics or reactive transport. For full job descriptions visit the LANL web site: http://careers.lanl.gov

EOE

Student Opportunities

Graduate Program in Engineering Physics Embry-Riddle Aeronautical University

The Department of Physical Sciences at Embry-Riddle Aeronautical University, located in Daytona Beach, FL (http://db.erau.edu/coas/ps) seeks applicants for its graduate program in Engineering Physics. Research areas include theory and modeling in atmospheric and space physics (aeronomy, neutral wave dynamics, auroral physics, ion-neutral coupling, ionosphere and magnetosphere), ground- and space-based remote sensing of the atmosphere and space environment, and rocket and satellite instrumentation. Full tuition waiver and $20,000/year stipend are available for qualified Ph.D. students. Additional forms of support via TA and RA positions are available for both Ph.D. and M.S. candidates.

The minimum requirement to the program is a BS or MS degree in engineering, physics, applied mathematics or related disciplines. For details on the curriculum and application procedures, please visit http://erau.edu/epphd/, email to dbphdep@erau.edu, or call Dr. Alan Liu at 386-226-6538.

PhD project in high-precision time-scale calibration (University of Geneva, Switzerland)

We seek applications for a PhD position in high-precision time calibration of the Triassic through U-Pb zircon geochronology of volcanic ashes inter-bedded with fossiliferous marine sediments. The multidisciplinary project will also involve high-resolution analyses of oxygen and carbon isotopes on rock and fossil samples, trace-element and Hf isotope analyses on accessory minerals from the dated ash beds, and Bayesian age modeling.

The project is funded for a period of three (usually extended to four) years. We invite applicants with a MSc., Diploma, high-ranking BSc. (honors; 1st class or 2-1) or equivalent degree in Earth Sciences. The successful candidate should have previous experience performing geochemical analyses in a clean laboratory environment, and an affinity for working with analytical equipment, especially mass spectrometers. The ideal candidate is demonstrably careful and disciplined, ambitious and keen on working in a multicultural and multilingual team. Current language of the isotope group is English; French courses are offered by University of Geneva during the summer vacation time. The project starts 1st October 2015. For more detailed descriptions see: http://cms.unige.ch/sciences/terre/en/jobs/jobs.php

Submit applications (including a CV, a list of three referees, and a statement about your motivation) as one pdf file to urs.schaltegger@unige.ch by April 1., 2015.

FACULTY POSITION IN EARTH SURFACE PROCESSES/GEOMORPHOLOGY

Division of Earth Sciences and Earth Observatory of Singapore invites applications for a tenure-track position in geomorphology/Earth surface processes with emphasis on the geomorphic response to climate and/or anthropogenic change. Specific areas of interest include (but are not limited to) physical, chemical, and/or biological aspects of Earth-surface dynamics and evolution or changes in the Earth's surface as a result of human and natural impacts. Research approaches should encompass some combination of field, laboratory, and modeling. We seek an individual with research interests that augment our existing strengths in Earth systems science and surficial processes. The Earth Observatory has strong technical resources in a region with convenient access to mountain ranges, large rivers, coastlines, and active volcanoes. This position is part of the continued expansion of the Division of Earth Sciences with the Earth Observatory of Singapore.

We invite candidates who have developed an internationally recognized, externally funded, multi-disciplinary research program to apply at the assistant to full professor level. Successful candidates will also be required to actively participate in our core undergraduate and graduate teaching and in the administration of the Division of Earth Sciences.

To apply, please submit the following materials to:
eos_humanresources@ntu.edu.sg

- Statement of research and teaching interests
- Curriculum vitae
- A copy of three relevant publications
- The names of three references who are familiar with your work

Further information about the Division of Earth Sciences and the Earth Observatory of Singapore is available at **www.earthobservatory.sg**, and to contact **cmrubin@ntu.edu.sg** for job specific information. Review of applications will continue until the position is filled.

NANYANG TECHNOLOGICAL UNIVERSITY

EARTH OBSERVATORY OF SINGAPORE

Postcard from the Field

Hello, Everyone,

I'm in the Artillery Mountains using a portable X-ray fluorescence analyzer to examine clastic sedimentary rocks—conglomerate and sandstone—for evidence of potassium, sodium, and calcium mobilization by low-temperature diagenetic alteration associated with basin brines. A rare cloudy day here in western Arizona.

Christy C.
University of Arizona graduate student; Arizona Geological Survey geoinformatics

View more postcards at *http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field*.